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ANNUAL REPORT

OF THE

BOARD OF REGENTS

OF THE

SMITHSONIAN INSTITUTION,

SHOWING

THE OPERATIONS, EXPENDITURES, AND CONDITION OF THE INSTITUTION
FOR THE YEAR 1872.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1873.

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IN THE SENATE OF THE UNITED STATES,
February 3, 1873.

The following resolution, originating in the Senate December 20, 1872, was agreed to by the House of Representatives January 31, 1873.

Resolved, (the House of Representatives concurring,) That twelve thousand five hundred additional copies of the report of the Smithsonian Institution for the year 1872, be printed; twenty-five hundred of which shall be for the use of the Senate, five thousand for the use of the House, and five thousand for the use of the Institution: *Provided*, That the aggregate number of pages of said report shall not exceed four hundred and fifty, and that there shall be no illustrations except those furnished by the Smithsonian Institution.

Attest:

GEORGE C. GORHAM, *Secretary.*

LETTER

FROM THE

SECRETARY OF THE SMITHSONIAN INSTITUTION,

TRANSMITTING

The annual report of the Smithsonian Institution for the year 1872.

SMITHSONIAN INSTITUTION,
Washington, February 20, 1873.

SIR: In behalf of the Board of Regents, I have the honor to submit to the Congress of the United States the annual report of the operations, expenditures, and condition of the Smithsonian Institution for the year 1872.

I have the honor to be, very respectfully, your obedient servant,

JOSEPH HENRY,
Secretary Smithsonian Institution.

Hon. S. COLFAX,
President of the Senate.
Hon. J. G. BLAINE,
Speaker of the House of Representatives.

ANNUAL REPORT OF THE SMITHSONIAN INSTITUTION FOR 1872.

This document contains: 1. The programme of organization of the Smithsonian Institution. 2. The annual report of the Secretary, giving an account of the operations and condition of the establishment for the year 1872, with the statistics of collections, exchanges, meteorology, &c. 3. The report of the executive committee, exhibiting the financial affairs of the Institution, including a statement of the Smithson fund, the receipts and expenditures for the year 1872, and the estimates for 1873. 4. The proceedings of the Board of Regents. 5. A general appendix, consisting principally of reports of lectures, translations from foreign journals of articles not generally accessible, but of interest to meteorologists, correspondents of the Institution, teachers, and others interested in the promotion of knowledge.

THE SMITHSONIAN INSTITUTION.

ULYSSES S. GRANT	President of the United States, *ex-officio* Presiding Officer of the Institution.
SALMON P. CHASE	Chief Justice of the United States, Chancellor of the Institution, President of the Board of Regents.
JOSEPH HENRY	Secretary (or Director) of the Institution.

REGENTS OF THE INSTITUTION.

S. P. CHASE	Chief Justice of the United States, *President of the Board.*
S. COLFAX	Vice-President of the United States.
HENRY D. COOKE	Governor of the District of Columbia.
L. TRUMBULL	Member of the Senate of the United States.
J. W. STEVENSON	Member of the Senate of the United States.
H. HAMLIN	Member of the Senate of the United States.
J. A. GARFIELD	Member of the House of Representatives.
L. P. POLAND	Member of the House of Representatives.
S. S. COX	Member of the House of Representatives.
W. B. ASTOR	Citizen of New York.
T. D. WOOLSEY	Citizen of Connecticut.
L. AGASSIZ	Citizen of Massachusetts.
JOHN MACLEAN	Citizen of New Jersey.
PETER PARKER	Citizen of Washington.
WILLIAM T. SHERMAN	Citizen of Washington.

EXECUTIVE COMMITTEE OF THE BOARD OF REGENTS.

PETER PARKER. JOHN MACLEAN. WILLIAM T. SHERMAN.

MEMBERS EX-OFFICIO OF THE INSTITUTION.

U. S. GRANT	President of the United States.
S. COLFAX	Vice-President of the United States.
S. P. CHASE	Chief Justice of the United States.
H. FISH	Secretary of State.
G. S. BOUTWELL	Secretary of the Treasury.
W. W. BELKNAP	Secretary of War.
G. M. ROBESON	Secretary of the Navy.
J. A. J. CRESWELL	Postmaster-General.
C. DELANO	Secretary of the Interior.
GEO. H. WILLIAMS	Attorney-General.
M. D. LEGGETT	Commissioner of Patents.
H. D. COOKE	Governor of the District of Columbia.

OFFICERS OF THE INSTITUTION, 1872.

JOSEPH HENRY, SECRETARY,

Director of the Institution.

SPENCER F. BAIRD,

Assistant Secretary.

WILLIAM J. RHEES,

Chief Clerk.

DANIEL LEECH,

Corresponding Clerk.

CLARENCE B. YOUNG,

Book-keeper.

HERMANN DIEBITSCH,

Meteorological Clerk.

HENRY M. BANNISTER,

Museum Clerk.

JANE A. TURNER,

Exchange Clerk.

SOLOMON G. BROWN,

Transportation Clerk.

JOSEPH HERRON,

Janitor.

PROGRAMME OF ORGANIZATION

OF THE

SMITHSONIAN INSTITUTION.

[PRESENTED IN THE FIRST ANNUAL REPORT OF THE SECRETARY, AND ADOPTED BY THE BOARD OF REGENTS, DECEMBER 13, 1847.]

INTRODUCTION.

General considerations which should serve as a guide in adopting a Plan of Organization.

1. **Will of Smithson.** The property is bequeathed to the United States of America, "to found at Washington, under the name of the Smithsonian Institution, an establishment for the increase and diffusion of knowledge among men."

2. The bequest is for the benefit of mankind. The Government of the United States is merely a trustee to carry out the design of the testator.

3. The Institution is not a national establishment, as is frequently supposed, but the establishment of an individual, and is to bear and perpetuate his name.

4. The objects of the Institution are, 1st, to increase, and 2d, to diffuse knowledge among men.

5. These two objects should not be confounded with one another. The first is to enlarge the existing stock of knowledge by the addition of new truths; and the second, to disseminate knowledge, thus increased, among men.

6. The will makes no restriction in favor of any particular kind of knowledge; hence all branches are entitled to a share of attention.

7. Knowledge can be increased by different methods of facilitating and promoting the discovery of new truths; and can be most extensively diffused among men by means of the press.

8. To effect the greatest amount of good, the organization should be such as to enable the Institution to produce results, in the way of increasing and diffusing knowledge, which cannot be produced either at all or so efficiently by the existing institutions in our country.

9. The organization should also be such as can be adopted provisionally; can be easily reduced to practice; receive modifications, or be abandoned, in whole or in part, without a sacrifice of the funds.

10. In order to compensate in some measure for the loss of time occasioned by the delay of eight years in establishing the Institution, a considerable portion of the interest which has accrued should be added to the principal.

11. In proportion to the wide field of knowledge to be cultivated, the funds are small. Economy should, therefore, be consulted in the construction of the building; and not only the first cost of the edifice should be considered, but also the continual expense of keeping it in repair, and of the support of the establishment necessarily connected with it. There should also be but few individuals permanently supported by the Institution.

12. The plan and dimensions of the building should be determined by the plan of organization, and not the converse.

13. It should be recollected that mankind in general are to be benefited by the bequest, and that, therefore, all unnecessary expenditure on local objects would be a perversion of the trust.

14. Besides the foregoing considerations, deduced immediately from the will of Smithson, regard must be had to certain requirements of the act of Congress establishing the Institution. These are, a library, a museum, and a gallery of art, with a building on a liberal scale to contain them.

SECTION I.

Plan of organization of the Institution in accordance with the foregoing deductions from the will of Smithson.

TO INCREASE KNOWLEDGE. It is proposed—

1. To stimulate men of talent to make original researches, by offering suitable rewards for memoirs containing new truths; and,

2. To appropriate annually a portion of the income for particular researches, under the direction of suitable persons.

TO DIFFUSE KNOWLEDGE. It is proposed—

1. To publish a series of periodical reports on the progress of the different branches of knowledge; and,

2. To publish occasionally separate treatises on subjects of general interest.

DETAILS OF THE PLAN TO INCREASE KNOWLEDGE.

I. *By stimulating researches.*

1. Facilities afforded for the production of original memoirs on all branches of knowledge.

2. The memoirs thus obtained to be published in a series of volumes, in a quarto form, and entitled Smithsonian Contributions to Knowledge.

3. No memoir on subjects of physical science to be accepted for publication which does not furnish a positive addition to human knowledge, resting on original research; and all unverified speculations to be rejected.

4. Each memoir presented to the Institution to be submitted for examination to a commission of persons of reputation for learning in the branch to which the memoir pertains; and to be accepted for publication only in case the report of this commission is favorable.

5. The commission to be chosen by the officers of the Institution, and the name of the author, as far as practicable, concealed, unless a favorable decision is made.

6. The volumes of the memoirs to be exchanged for the transactions of literary and scientific societies, and copies to be given to all the colleges and principal libraries in this country. One part of the remaining copies may be offered for sale, and the other carefully preserved, to form complete sets of the work, to supply the demand from new institutions.

7. An abstract, or popular account, of the contents of these memoirs to be given to the public through the annual report of the Regents to Congress.

II. *By appropriating a part of the income, annually, to special objects of research, under the direction of suitable persons.*

1. The objects, and the amount appropriated, to be recommended by counselors of the Institution.

2. Appropriations in different years to different objects; so that in course of time each branch of knowledge may receive a share.

3. The results obtained from these appropriations to be published, with the memoirs before mentioned, in the volumes of the Smithsonian Contributions to Knowledge.

4. Examples of objects for which appropriations may be made:

(1.) System of extended meteorological observations for solving the problem of American storms.

(2.) Explorations in descriptive natural history, and geological, magnetical, and topographical surveys, to collect materials for the formation of a physical atlas of the United States.

(3.) Solution of experimental problems, such as a new determination of the weight of the earth, of the velocity of electricity, and of light; chemical analysis of soils and plants; collection and publication of scientific facts accumulated in the offices of Government.

(4.) Institution of statistical inquiries with reference to physical, moral, and political subjects.

(5.) Historical researches, and accurate surveys of places celebrated in American history.

(6.) Ethnological researches, particularly with reference to the different races of men in North America; also, explorations and accurate surveys of the mounds and other remains of the ancient people of our country.

DETAILS OF THE PLAN FOR DIFFUSING KNOWLEDGE.

I. *By the publication of a series of reports, giving an account of the new discoveries in science, and of the changes made from year to year in all branches of knowledge not strictly professional.*

1. These reports will diffuse a kind of knowledge generally interesting, but which, at present, is inaccessible to the public. Some of the reports may be published annually, others at longer intervals, as the income of the Institution or the changes in the branches of knowledge may indicate.

2. The reports are to be prepared by collaborators eminent in the different branches of knowledge.

3. Each collaborator to be furnished with the journals and publications, domestic and foreign, necessary to the compilation of his report; to be paid a certain sum for his labors, and to be named on the title-page of the report.

4. The reports to be published in separate parts, so that persons interested in a particular branch can procure the parts relating to it without purchasing the whole.

5. These reports may be presented to Congress, for partial distribution, the remaining copies to be given to literary and scientific institutions, and sold to individnals for a moderate price.

II. *By the publication of separate treatises on subjects of general interest.*

1. These treatises may occasionally consist of valuable memoirs, translated from foreign languages, or of articles prepared under the direction of the Institution, or procured by offering premiums for the best exposition of a given subject.

2. The treatises should, in all cases, be submitted to a commission of competent judges, previous to their publication.

3. As examples of these treatises, expositions may be obtained of the present state of the several branches of knowledge mentioned in the table of reports.

SECTION II.

Plan of organization in accordance with the terms of the resolution of the Board of Regents providing for the two modes of increasing and diffusing knowledge.

1. The act of Congress establishing the Institution contemplated the formation of a library and a museum; and the Board of Regents, in-

cluding these objects in the plan of organization, resolved to divide the income into two equal parts.

2. One part to be appropriated to increase and diffuse knowledge by means of publications and researches, agreeably to the scheme before given. The other part to be appropriated to the formation of a library and a collection of objects of nature and art.

3. These two plans are not incompatible with one another.

4. To carry out the plan before described, a library will be required, consisting, 1st, of a complete collection of the transactions and proceedings of all the learned societies in the world; 2d, of the more important current periodical publications, and other works necessary in preparing the periodical reports.

5. The Institution should make special collections. particularly of objects to illustrate and verify its own publications.

6. Also, a collection of instruments of research in all branches of experimental science.

7. With reference to the collection of books other than those mentioned above, catalogues of all the different libraries in the United States should be procured, in order that the valuable books first purchased may be such as are not to be found in the United States.

8. Also, catalogues of memoirs, and of books and other materials, should be collected for rendering the Institution a center of bibliographical knowledge, whence the student may be directed to any work which he may require.

9. It is believed that the collections in natural history will increase by donation as rapidly as the income of the Institution can make provision for their reception, and, therefore, it will seldom be necessary to purchase articles of this kind.

10. Attempts should be made to secure for the gallery of art casts of the most celebrated articles of ancient and modern sculpture.

11. The arts may be encouraged by providing a room, free of expense, for the exhibition of the objects of the Art-Union and other similar societies.

12. A small appropriation should annually be made for models of antiquities, such as those of the remains of ancient temples, &c.

13. For the present, or until the building is fully completed, besides the Secretary, no permanent assistant will be required, except one, to act as librarian.

14. The Secretary, by the law of Congress, is alone responsible to the Regents. He shall take charge of the building and property, keep a record of proceedings, discharge the duties of librarian and keeper of the museum, and may, with the consent of the Regents, *employ assistants.*

15. The Secretary and his assistants, during the session of Congress, will be required to illustrate new discoveries in science, and to exhibit

new objects of art. Distinguished individuals should also be invited to give lectures on subjects of general interest.

The foregoing programme was that of the general policy of the Institution until 1866, when Congress took charge of the library; and since an appropriation has been made by Government for the maintenance of the museum the provisions of Section II are no longer fully observed.

REPORT OF THE SECRETARY FOR THE YEAR 1872.

To the Board of Regents of the Smithsonian Institution:

GENTLEMEN: The report which I have the honor to present at this time completes the history of the operations of the Smithsonian Institution for the first quarter of a century of its active existence; and as it is important to recapitulate, from time to time, the policy which has been adopted for the management of the funds intrusted to the United States for the good of men by James Smithson, it may be well on this occasion to recall the essential features of the trust, and to briefly state such salient points connected with its administration as may be of especial importance in the future.

At the time the funds were received by the General Government, the distinction between education and original scientific research was not so fully recognized as it is at the present day, and therefore it is not surprising that the brief though comprehensive language in which the will of Smithson was expressed should not have been generally understood, or that the words "I bequeath the whole of my property to the United States of America, to found at Washington, under the name of the Smithsonian Institution, an establishment for the *increase* and *diffusion* of knowledge *among men*," should have been so interpreted as to induce Congress to direct the expenditure of the income of the fund principally to objects which, though important in themselves, did not comport with the strict interpretation of the will, being of a local character instead of affecting the interests of humanity in general.

Smithson devoted his life to abstract science and original research, and there cannot be a reasonable doubt that he used the terms "increase and diffusion of knowledge among men"* to imply that the income of his bequest should be devoted to original research in all branches of knowledge susceptible of increase, and the diffusion of the result of this through the press for the benefit of mankind generally.

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* The terms *increase* and *diffusion* of knowledge were used, in the specific sense here indicated, by men of science of the time of Smithson. As an illustration of this we may cite the following remark of William Swainson, a celebrated naturalist. Speaking of the Zoological Society of London, he says: "It is more calculated to *diffuse* than to *increase* the actual stock of scientific knowledge." The author further remarks that, "while we may truly exult in this awakening of the national intellect, we must remember that *diffusion* and *advancement* are two very different processes; and each may exist independent of the other. It is very essential, therefore, to our present purpose, when we speak of the *diffusion* or *extension* of science, that we do not confound these stages of development with *discovery* or *advancement;* since the latter may be as different from the former as depth is from shallowness." (See Cabinet Cyclopedia, Natural History, p. 314, London, 1834.)

The terms of the will, when critically analyzed in their scientific signification, will admit of no other interpretation, and the fitness of the policy which has been adopted after much discussion, and, as far as the original restrictions of Congress would allow, has met with general approval by men of science of all countries.

After having devoted assiduously twenty-five of the best years of my life to the administration of the affairs of the Institution, I may be pardoned for making some personal allusions to the past, and expressing my earnest desire that the same policy which was inaugurated and has been continually observed under my direction may be continued in the future, when I shall have ended my connection with the establishment, with only such modifications as the ever-changing conditions of the world may render necessary.

Immediately after the organization of the Institution, in 1846, I was requested by personal friends in the Board of Regents to give my views as to what the Institution ought to be, in order to realize the intention of the founder as expressed in his will. Having been long impressed with the importance of special provision for original research, and believing it was the intention of the founder of the Smithsonian Institution to offer facilities for this purpose, I suggested the essential features of the programme published in my first report to the Board of Regents in 1847; and, on account of this suggestion I presume, I was informed that if I would accept the position of Secretary, or rather director, of the establishment, I would receive the appointment.

Being at the time engaged in a series of original researches, I did not at first entertain the proposition; but afterward, on the expression of the opinion of the more prominent members of the American Philosophical Society that it was my duty, as the only scientific candidate that had been proposed, to accept the appointment, I accordingly consented, was elected, and entered upon my duty; not, however, without much anxiety and great solicitude as to my ability in the line of administration, but with the hope that the policy which I wished to inaugurate would be readily understood and properly appreciated; that my plans would be immediately adopted; and that, after seeing the Institution fully under way in the direction proposed, I might retire from its charge, return to my former position in the College of New Jersey, and resume my scientific investigations. In this, however, I was sadly disappointed.

The plan proposed was too much in advance of the popular intelligence of the day, both in this country and in England, to be immediately adopted. The value of scientific research had not then received that high appreciation which it enjoys at the present time; and, indeed, no distinction was then made between the popular expounder of scientific principles and the original investigator, to whose labors the world was indebted for important additions to human knowledge.

Opposed to the views of establishing an institution the great feature of which should be the facilitating of original research, was the organization which had been directed by Congress, namely, that provision should be made on a liberal scale for a museum, a library, a gallery of art, lectures, and an arboretum, involving the construction of a large building, whereas the plan for original research required a building of comparatively small dimensions, the cost of which need not to have exceeded $50,000; while the estimated cost of the one proposed was $250,000, and it has actually cost more than double that sum. It was in vain to urge that the law of Congress might be altered, although the will of Smithson could never be changed. Public opinion apparently was generally in favor of the erection of a large building, and the establishment of a library, museum, gallery of art, and lectures. Still a majority of the Board of Regents were in favor of the plan of original research and publication, and, after much discussion, it was finally agreed, as an experiment, to divide the income into two equal parts, giving one part to what has been called the "active operations," and the other to the library, museum, and other local objects. In the attempt to carry out this division, difficulties occurred which led to its final abandonment, and to the adoption of another arrangement, that of making such provision from time to time for the museum and library and gallery of art as might be thought necessary under existing conditions. As might have been anticipated, the cost of the building far exceeded the original estimate, and the multiplicity of objects was far too great to be sustained by the comparatively small income of the establishment. The increase of the library, by exchanges for the publications of the Institution, itself was so rapid that the care and binding of the books alone absorbed a considerable part of the income.

The collections of natural history and ethnology belonging to the Government were transferred to the care of the Institution, and an allowance of only $4,000 annually made for their support, while, as the number of specimens was continually increasing, the sum allowed by Congress finally scarcely paid more than one-fourth the actual expenses, without estimating the rent and cost of repair of the building. Besides this, Congress had presented to the Institution a portion of the public reservation on which the building is situated. In the planting of this with trees, nearly $10,000 of the Smithson income were expended.

It is readily seen from this statement that with the increase of the library and museum, the formation of a gallery of art, and the sustaining of a public park, all the income would be absorbed, and the cherished plan of an institution to facilitate original research, and the publication of its results, must be abandoned.

To prevent so undesirable a result, advantage was taken of the exposure of the books after the fire, to urge the plan of uniting the library of the Institution with that of Congress, and of the two to form a collection worthy the name of National Library. The proposition was adopted, and the results have proved eminently successful. The Library of Congress is now the largest in the United States, the scientific part of which is rapidly becoming, through the Smithsonian exchanges, one of the best of the kind in the world. Furthermore, Congress is now about to erect a separate building for its accommodation.

Previous to this union of the libraries, however, an appropriation had been made by Congress for improving the public ground between the Potomac and the Capitol. Advantage was taken of this to include the Smithsonian portion of these grounds in the general plan, and thus to relieve the Institution from the cost of its maintenance.

The remaining drains upon the income, which continued to diminish the active operations, were the care of the building and the maintenance of the museum; and the next step, therefore, was to induce Congess to relieve the Institution from these. The results, in the mean time, of the active operations having signally demonstrated the importance of original research and publications, together with the general system of exchanges which had been adopted, Congress finally lent a favorable ear to the petition for appropriations sufficient to support the museum, and now annually appropriates $15,000 to this purpose.

In justice to the trust, however, the Government ought to do much more than this. It should repay at least a portion of the $600,000 which have been expended on the building, erected in accordance with the instruction of Congress, and far exceeding in cost an edifice wanted for the legitimate objects of the Institution. The proper course to adopt would be for Congress to take entire possession of the building for the National Museum, repay the Smithson fund, say $300,000, adding $200,000 of this to the principal of the trust-fund, and applying the remainder to the erection of a separate building, consisting of offices, laboratories, store-rooms, &c., required for the present use of the Institution.

The only other requirement of Congress which has not been fully met is that of a gallery of art. It is true the Institution owns a very valuable collection of specimens of the early masters to illustrate the progress of the art of engraving, and some articles of painting and sculpture, which may be considered as forming the commencement of a gallery of art; but the expense of supporting a collection of this kind has been obviated by the establishment in this city of a gallery of art by the liberality of Mr. W. W. Corcoran, with an income larger than all of that from the Smithson fund.

Notwithstanding the various burdens which have interfered with the full development of the plan of active operations, it is through this plan that the Institution has made itself known throughout every part of the civilized world. The publications which result from the facilities it has afforded to original research are to be found in all the principal libraries, and its specimens in all the great public museums of the world. And it is hoped that in future, with the appropriations of Congress for the support of the museum, still more important results will be obtained.

The success of the plan for realizing the intentions of Smithson for increasing and diffusing knowledge among men has been due to its simplicity and efficiency. Under a Board of Regents, which holds its sessions once a year, the operations of the establishment are directed by a single individual, called the Secretary, who, with the consent of the Regents, employs assistants and disburses the income of the fund. In determining the appropriations to different objects of research, the advice of persons of established reputation in different branches of science is obtained, and in all cases, before an article is accepted for publication, it is submitted to a commission of experts, who report upon its fitness for adoption by the Institution. In order to obtain a free and unbiased judgment, the name of the author, as far as possible, is concealed from the examiners, and the names of the latter are unknown to the former. By adopting this course the Institution secures the co-operation of the best minds of the country, and in some cases has called in the aid of foreign *savans*. It is gratifying to be able to state that in no instance has aid of this kind been declined. In this way the greatest amount of mental labor is secured with a given expenditure of funds. It is true the plan might have been adopted of electing men of original research in the various branches of science, and supporting them entirely on the funds of the establishment; but the income was not sufficient for this purpose, as will be evident when the fact is considered that the will includes all branches of knowledge, and that every subject susceptible of increase is entitled to the benefit of the funds. At the beginning, however, since Congress directed the formation of a library and a museum, it was necessary that the Secretary should have assistants to take especial charge of these two branches of the establishment. With the transfer of the library to the care of the Government, a librarian of the Institution has been dispensed with; but since the museum is still under the care of the Institution, an assistant in charge of this is still required, and Professor Baird, who has acted as assistant secretary, has had charge of the museum, and has rendered important service, not only in the line of natural history, but in that of the general operations of the establishment.

The greatest opposition to the plan of active operations was made by the friends of the establishment of a library, but they have finally acquiesced in the propriety of the course which has been pursued. The number of books of the first class which the Institution is bringing into the country through its system of exchange, and which are distributed to all the large cities of the United States, more than compensates for the support of a restricted library in the city of Washington by the funds of the Institution.

The plan in regard to the museum was also at first misunderstood. It was supposed that because the Secretary opposed the establishment of a museum at the expense of the Institution that he was not well disposed toward the advance of natural history. But this misapprehension can readily be removed by the consideration that natural history could be much more effectually advanced by expending less than a moiety of the cost of the building for the museum and the support of the collections, in original explorations, in collecting specimens not to be preserved, but to be distributed to all who might have the desire and ability to investigate special problems in this branch of knowledge. The policy in regard to natural history is that of making collections of large numbers of duplicate specimens to illustrate the natural productions of North America, to make these up into sets, reserving one for the National Museum, and distributing all the others for scientific and educational purposes to the museums of the world. In every case in which application has been made to the Institution by an original investigator from any part of the world for specimens connected with his researches, they have been sent to him as far as possible, assurance being given that the specimens would be properly used and full credit given to the name of Smithson. As the specimens are collected, as a general rule, they are submitted to specialists in the various branches of natural history, who, without charge, classify, arrange, and label them for distribution. In this way the Institution has done much for natural history; but it is evident that it could have done much more had it not been obliged to support a public museum at the expense of several hundred thousand dollars for an edifice for this purpose.

One prominent maxim of the Institution has been "co-operation not monopoly," and another, "in all cases, as far as possible, not to occupy ground especially cultivated by other establishments," or, in other words, not to expend the money of the bequest in doing that for which provision could be obtained through other means. To gratify men of literature as well as to advance an important branch of knowledge, from the first much attention has been given to anthropology, including linguistics, antiquities, and everything which tends to reconstruct the history of man in the past; this being a common ground on which the man of letters and of science could meet as harmonious collaborators.

From the foregoing sketch it will be evident that the theory of the Institution is that of an ideal establishment for the collection of facts, the elaboration of these into general principles, and a diffusion of the results among men of every race and of every clime. That an institution of this character, in which the accumulation of ideas and not merely of material objects is the great end, should not have been properly appreciated at first in a country so eminently practical as ours is not surprising. But we are happy in knowing it has been from year to year growing in public estimation, and we are encouraged to cherish the belief that it will not only realize the ideas of the benevolent founder of the Institution, but also serve as an example of imitation, while the errors which may have been committed will also be of service in an opposite way.

There is one feature of the establishment ordained by Congress which is worthy of imitation in the conduct of all endowments for benevolent objects, namely, the restriction of all expenditures to the annual interest. This rule has been rigorously adhered to in the conduct of the Institution, and after expending, in accordance with the act of Congress, upward of $600,000 on the buildings, the original fund remains intact with an addition made to it of upward of $150,000 by savings, judicious investments, &c.

FINANCES.

The following is a general statement of the condition of the funds at the beginning of the year 1873:

The amount originally received as the bequest of James Smithson, of England, deposited in the Treasury of the United States, in accordance with the act of Congress of August 10, 1846	$515,169 00
The residuary legacy of Smithson, received in 1865, deposited in the Treasury of the United States, in accordance with the act of Congress of February 8, 1867	26,210 63
Total bequest of Smithson	541,379 63
Amount deposited in the Treasury of the United States, as authorized by act of Congress of February 8, 1867, as derived from savings of income and increase in value of investments	108,620 37
Total permanent Smithson fund in the Treasury of the United States, bearing interest at 6 per cent., payable semi-annually in gold	650,000 00
In addition, there remains of the extra fund from savings, &c., in Virginia bonds, at par, $88,125.20, now valued at	37,000 00
The balance in First National Bank 1st of January, 1873	17,811 30
Total Smithson funds 1st January, 1873	704,811 30
The income of the Smithson fund during the year, including premium on gold, was	46,916 45
The expenditures were	45,420 11
Leaving a balance of	1,496 34

To be added to the balance at the beginning of the year 1872.

Included in the income was $3,004.90 derived from back interest on the Virginia bonds. The value of these bonds has appreciated during the year.

PUBLICATIONS.

The publications of the Institution are of three classes—the Contributions to Knowledge, the Miscellaneous Collections, and the Annual Reports. The first consist of memoirs containing positive additions to science resting on original research, and which are generally the result of investigations to which the Institution has in some way rendered assistance, or of such an expensive character as cannot otherwise be published. The Miscellaneous Collections are composed of works intended to facilitate the study of branches of natural history, meteorology, &c., and are designed especially to induce individuals to engage in studies as specialties. The Annual Reports, beside an account of the operations, expenditures, and condition of the Institution, contain translations from works not generally accessible to American students, reports of lectures, extracts from correspondence, &c.

The following are the rules which have been adopted for the distribution of these publications:

1st. They are presented to learned societies of the first class which in return give complete series of their publications to the Institution.

2d. To libraries of the first class which give in exchange their catalogues and other publications, or an equivalent, from their duplicate volumes.

3d. To colleges of the first class which furnish meteorological observations, catalogues of their libraries and of their students, and all other publications relative to their organization and history.

4th. To States and Territories, provided they give in return copies of all documents published under their authority.

5th. To public libraries in this country, not included in any of the foregoing classes, containing 15,000 volumes, especially if no other copies are given in the same place, and to smaller libraries where a large district would be otherwise unsupplied.

6th. To institutions devoted exclusively to the promotion of particular branches of knowledge are given such of the publications as relate to their respective objects.

7th. The Reports are presented to the meteorological observers, to contributors of valuable material to the library or collections, and to persons engaged in special scientific research.

The distribution of the publications of the Institution is a matter which requires much care and a judicious selection of recipients, the great object being to make known to the world the truths which may result from the expenditure of the Smithson fund. For this purpose, the principal class of publications, namely, the Contributions, are so distributed as to be accessible to the greatest number of readers, and this is evidently to principal libraries.

The volumes of Contributions are presented on the express condition that while they are to be carefully preserved they are to be accessible to students and others who may desire to consult them. These works, it must be recollected, are not of a popular character, but require profound study to fully understand them. They are, however, of immense importance to the teacher and the popular expounder of science. They contain the materials from which general treatises on special subjects are elaborated.

Full sets of the publications cannot be given to all who apply for them, since this will be impossible with the limited income of the Institution; and, indeed, if care be not exercised in the distribution, so large a portion of the income will be annually expended on the distribution of what has already been printed that nothing further can be done in the way of new publications. It must be recollected that every addition to the list of distribution not only involves the giving of publications which have already been made but also of those which are to be made hereafter.

At the commencement of the operations of the Institution the publications were not stereotyped, and consequently the earlier volumes have now become scarce, especially the *first*, of which there are no copies for distribution, although it can occasionally be obtained at a second-hand book-store in some of the larger cities, the authors having been allowed to strike off an edition to sell on their own account.

No copyright has ever been taken for any of the publications of the Institution. They are left free to be used by the compiler of books without any restrictions except the one that full credit shall be given to the name of Smithson for any extracts which may be made from them.

The printing of the publications of the Institution almost since the organization has been principally done at Philadelphia, by the house of T. K. Collins, under the superintendence of Mr. J. W. Huff, whose accuracy and typographical skill leave us nothing to desire in this line. The stereotype plates are all deposited in the fire-proof vault of the basement of the Academy of Natural Science, Philadelphia; and to this society the Institution has been indebted many years for the courtesy of storing, free of cost, this valuable property.

Publications in 1872.—During the past year the volume of Tables and Results of the Precipitation in *Rain* and *Snow* in the United States and at some stations in adjacent parts of North America, Central and South America, has been printed and partly distributed. It consists of 178 quarto pages, with five plates and three charts. It contains the abstracts of all the records of observations of the rain-fall which have been made from the early settlement of this country down to the close of the year 1866, so far as they could be obtained. These records are from about twelve hundred stations, and consist of the observations made under the direction of the Institution, assisted since 1854 by the Patent-Office and Department of Agriculture, of those of the Medical Department of the United States Army, of those by the United States Survey of the North and Northwest Lakes, of those made by the New York University system, by the Franklin Institute in Philadelphia, and also of those by other scientific institutions and individuals. During the past year the compilers have completed the tables of rain for 600 Smithsonian stations for the years 1868, 1869, and 1870, and of 220 military posts from December, 1864, to November, 1871. The result of all the observations has been incorporated in the charts published in 1872, but the tables will be combined with those already published at some future time.

It is proper here to express our obligations for the valuable co-operation of the Medical Department of the Army, under Surgeon-General Barnes, who has given us free access to all the unpublished records; and also for that of the Department of Agriculture, under its former commissioner, General Capron. These tables furnish the means for important deductions intimately connected with the agriculture, commerce, and mechanical industry of the country, while they constitute a valuable contribution to the physical geography of the globe.

This memoir is one of a series embodying the results of all the labors of the Smithsonian Institution in regard to the meteorology of the United States. These will include not only all the observations which have been made under its own direction, but also the discussion of all that has been made by other parties. The whole series will embrace the tabulation and discussion of observations on the temperature, atmospheric pressure, direction and force of the wind, moisture of the air, and miscellaneous phenomena.

Another work, that of Dr. Horatio C. Wood, jr., of Philadelphia, on the *fresh-water algæ*, was briefly noticed in the report for 1870. It forms a complement to the great work on the marine algæ by Dr. Harvey, published in 1858 by the Smithsonian Institution. It is illustrated by numerous drawings, made principally under the microscope, and will serve to illustrate an obscure department of botany, and also to furnish the means by which investigators of minute microscopical organisms may compare recent and fossil forms. The work was presented to the American Philosophical Society and also to the Academy of Natural Sciences of Philadelphia, but the expense of the engravings prevented either of these societies from undertaking its publication, although it was considered entirely worthy of their adoption. It was referred by the Institution to Dr. Torrey and Professor Barnard for critical examination, and published on their recommendation.

A large part of the material for this work was gathered by Dr. Wood himself, although he was indebted to several persons for aid, especially to Dr. J. S. Billings, of the United States Army, for collections made near Washington; to Professor Ravenel, of South Carolina, for collections in Texas, South Carolina, and Georgia; to Mr. C. J. Austin for specimens gathered in Northern New Jersey; to Mr. William Canby for collections obtained in Florida; to Professor Sereno Watson for others from the Rocky Mountains; and to Dr. Lewis for specimens from the White Mountains. The work embraces all families of the fresh-water algæ except the diatomaceæ, which are so numerous as to constitute in themselves a special object of study.

The synonomy of Professor Rabenhorst has been generally followed, this naturalist having gone over the subject most thoroughly, with full access to all its literature. "To attempt to differ from him," says Dr. Wood, "would cause endless confusion. I have therefore nearly always contented myself with his dictum, and have referred to him as authority for the names adopted." The memoir in question consists of 272 pages, and is illustrated by 21 quarto-plates of a very expensive character, since they required in most cases a number of printings to produce the different colors.

Another investigation to the prosecution of which the Institution has contributed is that by Mr. William Ferrel relative to the *tides*. To this subject the author has given much attention, and has completed a memoir in regard to it, which is now in the press. This memoir does not purport to be a regular treatise on the tidal theory, but is for the most part supplementary to what has already been done. It does not, therefore, include elementary principles, but pertains principally to those parts of the general theory in which new results are attainable or old ones susceptible of being presented in a more concise and simple manner. For the author's purpose, however, it was necessary to go over much of the ground which had been investigated; but all those parts of the subject which had already been well treated are passed over with a mere reference as to where they might be found. At the time when this subject was treated by La Place, Young, and Airy, but few observations had been made and little attention had been given to the accurate comparison of the results of observation with those of theory, or to the formation of tables for the purpose of predicting the time of the phases of the tides. For accomplishing the result it is necessary to obtain not only an accurate development of the solar and lunar disturbing forces, but also to determine the expressions which shall represent most accurately the tidal relations to any one part of the whole of these disturbing forces. "Every investigator of the tides," says the author, "must frequently have felt the great need of formulæ of this kind prepared to his hand, which he could use and thus save the labor of difficult developments and accurate determinations of co-efficients in special cases." This great need the author has attempted to supply.

Believing that most of the hitherto unexplained apparent anomalies in the tides are due to the friction of the water on the surface of the earth, the author has given special attention to the effects of this in all the various cases, not only on the hypothesis of its being in direct proportion to the velocity but also as the square of the velocity. The results obtained in this part of the investigation are regarded as being interesting and important in relation to some of the phenomena of the tides which have not hitherto been explained, especially to the occurrence of the greatest tides in the Atlantic one or two days after the time of the greatest force. A correct tidal theory should furnish the data for a determination of the moon's mass; and this determination should be the same for every port. Considering this as one of the best tests of any tidal theory, the author has given much attention to framing various equations from theory for this purpose, and to their application to the results of tidal observations at various ports. The comparisons are made with the extended series of observations of the United States Coast Survey and with the results obtained by the Tidal Committee of the British Association from the analysis of tidal observations of various ports by means of the harmonic method of analysis. The memoir also contains the discussion of the published series of observations of the French government at Brest, with a comparison of the results with theory, and a chapter on the retardation of the earth's rotation on account of the tides, and its effect upon the apparent secular variation of the moon's motion in its orbit.

Beside the labor expended on this memoir in the line of higher mathematics, it involves arithmetical computations of a very laborious character, the expense of which will be defrayed by the Institution.

The investigation of the orbit of Uranus, by Prof. S. Newcomb, of the National Observatory, was substantially completed in October last, and has since been entirely prepared for the press, with the exception of some final revision. Considerable additions and alterations are, however, still required in the appended tables, to be used for computing ephemerides of the planet; but these the author hopes to complete in a few months, so that the work may be put in the hands of the printer early in 1873.

This work, on which the author has been engaged for thirteen years, has absorbed the greater part of his leisure time from his duties in the National Observatory during the last five years. Its preparation not only involved abstruse mathematical discussions, but also arithmetical calculations of very great extent. The latter were made at the expense of the Institution; and through the assistance thus rendered, Professor Newcomb has been enabled to complete his important investigations without devoting his energies to labors which could be well performed by intelligence of a less valuable character.

The following remarks by the author of this work may here be considered in place:

"It will perhaps surprise those not especially devoted to astronomy to learn that, although the planet Neptune has been known for a quarter of a century, the positions of Uranus in all the astronomical ephemerides of Europe are still computed, without regard to the action of that body, from the old tables of Bouvard, dating back as far as 1820, the errors of which led to the discovery of Neptune in 1846. A result of this was that an occultation of Uranus by the moon, which occurred in 1871, was erroneously predicted by the Nautical Almanac to the extent of some six minutes, and in consequence a number of observers who were on the alert to see so rare a phenomenon missed it entirely. An outcry was raised against the almanac in consequence, but it was met by the remark that that work could use only such tables as were at its disposal, and that the construction of new ones corresponding to the present state of astronomy was now almost beyond the power of any individual, and could only be undertaken under the auspices of some sufficiently liberal government.

"The disinclination of astronomers to undertake such a work as this may be illustrated by the fact that the tables of Jupiter and Saturn, as well as those of Uranus, are more than fifty years old, and are, of course, considerably in error. The Astronomical Society of Germany has been engaged in preparing the data for new tables of Jupiter during the past five years, but I am not aware of any recent report of progress.

"The first chapter of the work gives an exposition of the method employed in calculating the action of the disturbing planets Jupiter, Saturn, and Neptune on the motion of Uranus. In the second chapter this method is illustrated by quite a detailed calculation of the perturbations of Uranus produced by Saturn, including, however, only those which are of the first order with respect to the disturbing force. In the third, the perturbations produced by Jupiter and Neptune are given, but the computations are not presented with the same detail. The fourth chapter opens with a preliminary investigation of the orbit of Saturn, using Hansen's perturbations and the Greenwich observations, the object being the accurate determination of the terms of the second order. This is followed by the computation of the terms of the second order produced by Saturn, which include those containing as a factor either the square of the mass of that planet, or the product of its mass by that of Jupiter or by that of Uranus. The most remarkable of these terms is one of very long period, in which the results differ materially from those of other authorities, including Le Verrier, Delaunay, Adams, and Hansen, who all agree among themselves. I cannot find any error in my work, and so must, of course, retain my own result, leaving it to future investigators to find the cause of the discrepancy. The difference is of such a nature that it cannot affect the computed position of the planet until after the lapse of more than a century.

"The sixth chapter gives a discussion of all the observations of Uranus which have been published and reduced in such a manner as to be made use of. The entire number is 3,763. The correction to a provisional theory given by each series of observations is deduced.

"The object of the seventh chapter is to apply such corrections to the elements of Uranus and the mass of Neptune that the observations shall be represented with the smallest possible outstanding errors. The mass of Neptune comes out $\frac{1}{19700}$, almost exactly the same as that found by Professor Peirce more than twenty years ago.

"The representation of the observations by the concluded theory will probably be regarded as good. The mean outstanding difference during each five years since the discovery of the planet only exceeds a second of arc in a single instance, namely, during the years 1822–'26, when it amounts to 1″.4. This agreement is very much better than any obtained before. Still the vast number of observations used, and the care taken to reduce them to a uniform standard, led me to believe a better representation possible; and the outstanding differences, minute though they be, follow a regular law, thus showing that they do not arise from the purely accidental errors of observation. How far they arise from errors in my own theoretical computations, how far from the reductions of the observations themselves, and how far from the unavoidable errors of the instruments, I am unable to say without further investigation. It would be desirable to learn whether they may be due to the action of a trans-Neptunian planet, but to do this would require an entire re-reduction of all the older observations. Such a work is on many accounts an astronomical desideratum, but it could not be undertaken except under the auspices of the Government.

"In the eighth chapter the general formulæ and elements are collected and expressed in the form most convenient for permanent use.

"The ninth and concluding chapter gives tables by which the position of the planet may be computed for any time between the Christian era and the year 2300."

It has been mentioned in several of the reports that the Institution has collected large numbers of vocabularies of the several Indian languages of North America, including those of the Indian tribes of Washington Territory, California, northwest coast, New Mexico, Arizona, and the prairies; that these had been placed in the hands of Mr. George Gibbs for critical study and revision; and that, after consultation with some of the principal philologists of the country, it had been concluded to publish them, as it were provisionally, as material for ethnological and linguistic investigations. During the past year Mr. Gibbs has devoted considerable time to the arrangement of these vocabularies, and has completed the preparation for the press of one of the sets, namely, that of the Selish language, which is now in the hands of the printer.*

In order to facilitate the re-arrangement of the collections of the National Museum, the Institution has requested experts in the various branches of zoology to prepare catalogues exhibiting the best arrangements of the several classes of the animal kingdom; the families, in each case, to be numbered in successive order, and the subfamilies to be indicated by letters, thus: "15, Canidæ; (15) *a*, Caninæ; (15) *b*, Megalotinæ," &c. It is intended that these numbers and letters shall be attached to the specimens or receptacles containing them, and thus the agency of an ordinary laborer, or one unconversant with the animals, can be utilized in sending for specimens, replacing them, and revising the collections.

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* Since the presentation of this report, the work in question has been stopped by the death of Mr. Gibbs, one of the most esteemed collaborators of the Institution.

In accordance with the requests made, Professor Gill has prepared three catalogues, one on the arrangement of the families of mollusks, referred to in previous reports; another on the arrangement of the families of mammals; and a third on the arrangement of the families of fishes. The last two were published in November, 1872.

The "arrangement of the families of mammals" embraces a list of the recent as well as extinct families and subfamilies of the class. Of these, 136 are recognized. These are combined under fourteen orders and three subclasses, the subclasses being those almost universally recognized at the present time—monodelphia, didelphia, and ornithodelphia. The orders of monodelphia have been segregated into two higher divisions, or "super-orders," equivalent to the educabilia and ineducabilia of Prince Bonaparte, but with other characters derived from the interior structure of the brain; the educabilia correspond with the archencephala and gyrencephala of Owen combined, and the ineducabilia to the lissencephala.

"Synoptical tables of characters of the subdivisions of mammals, with a catalogue of the genera," have been in part published in connection with and under cover of the arrangement of the families of mammals, embracing pages 43 to 98 of that work; only that portion embracing the orders of educabilia has been completed, the remaining portion having been necessarily deferred. In contrasted dichotomous tables are given characters successively of the (1) subclasses, (2) the orders of monodelphia, and (3) the suborders, (4) families, and (5) subfamilies of each group of the educabilian monodelphia. The "arrangement of the families of fishes" is limited to an enumeration of the surviving families of the class, and was especially prepared for immediate use. The group of "fishes" is considered as an artificial combination, and is divided into three classes—fishes proper, marsipobranchiates, and leptocardians. The three classes contain 244 families, of which the true fishes embrace 240; the marsipobranchiates, 3; and the leptocardians, only 1. The families of the fishes proper are combined under eighteen orders and three subclasses; the teleostein ganoidei and elasmobranchii differing in this last respect from Müller's—the most generally accepted—classification simply in the union of the ganoids and dipnoans. The greatest deviation from the current classifications is the constitution of the order teleocephali. In an extended introduction the reasons are given for the modifications suggested.

A large demand has been made for these catalogues for the arrangement of other museums and collections.

It was mentioned in the last report that a new edition of the List of

Foreign Correspondents of the Institution was in press. This work, containing all the later additions to the list, has been published, and is now in use by the Institution and its correspondents.

It was also stated that a List of the Scientific, Educational, and Literary Establishments in the United States was in press. This work, which was prepared by Mr. W. J. Rhees, the chief clerk of the Institution, has been published, and is of much service in the distribution of the publications of the Institution, as well as those of the different Departments of Government, and of educational establishments, and will be of assistance to members of Congress in the distribution of documents. It includes 8,575 titles of societies, libraries, &c., as follows:

Colleges, male and female, (so-called)	758
Academies, normal and high-schools	2,850
Law schools and libraries	53
Medical schools and libraries	221
Theological schools and libraries	127
Observatories	23
Scientific societies and libraries	94
Agricultural societies	1,082
Libraries, general	2,692
Asylums and hospitals	491
Asylums for insane	65
Asylums for deaf and dumb	38
Asylums for blind	30
Prisons having libraries	51

For the purpose of forming a general hypsometrical map of the North American continent and for collecting together, for permanent record and publication, the data on which such a map should be based, letters of request have been sent out in every direction likely to be available for such information, while the printed reports of the various governmental, military, and geological expeditions and of railroad and canal surveys have been consulted and made to render tribute. The whole of this work has been placed in charge of the topographer of the Post-Office Department, Mr. Walter L. Nicholson, who reports in regard to it as follows:

"Contributions, in manuscript, have been received from 312 engineers and other officers of railroad companies, furnishing a large body of valuable facts, which, with the heights shown on upward of 70 graphic profiles collected, give upward of 16,000 points more or less accurately determined, over the several States and Territories.

But great labor and perplexity have arisen from the discrepancies found to exist among many of the statements given, owing, chiefly, to the various planes of reference used in the surveys, and to the indefiniteness in their references; and great difficulty has been experienced in co-ordinating the items so as to refer them all to a common base, the mean level of the sea, while another source of incoherence remains from the non-return of answers from numerous railroad corporations, which have been applied to with all possible courtesy and with expression as to the value of the results sought. Unfortunately, many corporations and engineers have lost or taken no pains to preserve the record of their surveys.

These collections of heights have been copied in twenty-five quarto volumes, for preservation and convenience in collation. The heights are arranged under the names of places alphabetically, under the headings of the individual States, &c., for convenience of reference when published—giving county, specification of locality, and authority, with notes where required.

This large mass of material is, in greater part, copied in manuscript directly from the returns—the individual names to be finally cut off in slips and arranged alphabetically for printing. While this is being proceeded with, a map has been projected, to represent the mean results of these data, on a scale of five-millionth, size of map 52 inches by 39 inches, which will embrace the large area from 15° to 58° latitude, and, from east to west will take in Newfoundland, the Bermudas, the larger West India Islands, (to St. Thomas,) and on the northwest coast, Vancouver's Island and Queen Charlotte's Island, extending thus well up into Hudson's Bay and down to Central America."

This work will form the basis of a physical map, and will be useful for many purposes of reference other than that of hypsometry.

The report of the Institution for the year 1871 was presented to Congress, and ordered to be printed. A resolution was offered as usual ordering an extra number of copies; and the House of Representatives directed an edition of 20,000 copies. This number was reduced in the Senate to 12,500, and unfortunately, before an arrangement satisfactory to both branches of Congress could be made, the adjournment took place. Up to this time, however, no further action has been taken, and the Institution is still without extra copies for distribution.

As an offset to this disappointment, we are gratified to be able to state that a resolution passed Congress at the last session, directing that an edition of 2,000 copies of all the reports of which there were stereotype plates be printed for the use of the Institution for distribution to public libraries and especially to colleges and higher academies. The series of eight volumes thus reproduced includes the reports from the years 1863 to 1870, inclusive.

We doubt not that Congress before the close of the present session will order the Public Printer to strike off the usual number of copies from the stereotype plates of the report of 1871, and that we shall thus be enabled to gratify in some measure the increasing calls upon the Institution for copies of this document.

In addition to the report of the Secretary, giving an account of the operations, expenditures, &c., of the Institution, and the proceedings of the Board of Regents to the 4th of April, 1872, the report for 1871 contains a memoir of Sir John Frederic William Herschel, by N. S. Dodge, esq.; a eulogy on Joseph Fourier, by Arago; an account of Prof. Thomas Graham's scientific work, by William Odling; translations from the German of a lecture on the relation of the physical sciences to science in general, by Dr. Helmholtz; a lecture on alternate generation and parthenogenesis in the animal kingdom, by Dr. G. A. Kornhuber; a lecture on the present state of our knowledge of cryptogamous plants, by Henry William Reichardt; an original paper on the secular variations of the planetary orbits, by John N. Stockwell, being an abstract of the elaborate memoir published by the Institution in the Contributions to Knowledge; an original article on methods of interpolation applicable to the graduation of irregular series, such as tables of mortality, &c., by E. L. DeForest; a translation of the transactions of the Society of Physics and Natural History of Geneva from June, 1870, to June, 1871; the scientific instructions to Captain Hall's north polar expedition; together with a large number of articles on ethnology and meteorology.

EXCHANGES.

The labors of the Institution in promoting literary and scientific intercourse between this country and other parts of the world have been continued during the past year. The system of international exchanges includes not only all the principal libraries and important societies, but also a considerable number of the minor institutions of Europe. The following table exhibits the number of establishments in each country with which the Smithsonian is at present in correspondence:

Sweden	20
Norway	22
Iceland	2
Denmark	27
Russia	155
Holland	62
Germany	588
Switzerland	63
Belgium	105
France	229
Italy	156
Portugal	20
Spain	11
Great Britain and Ireland	336
Greece	7
Turkey	11
Africa	19

Asia	36
Australia	26
New Zealand	13
Polynesia	1
South America	36
West Indies	7
Mexico	9
Central America	2
British America	18
General	4
Total	1,985

As in previous years, the Institution has received important aid from various steamer and railroad lines in the way of free freights, without which the expense of carrying on the system would be far beyond the means at command. Acknowledgment is again due for the liberality of the following companies:

Pacific Mail Steamship Company.
Panama Railroad Company.
Pacific Steam Navigation Company.
New York and Mexico Steamship Company.
New York and Brazil Steamship Company.
North German Lloyd's Steamship Company.
Hamburg American Packet Company.
French Transatlantic Company.
North Baltic Lloyd's Steamship Company.
Inman Steamship Company.
Cunard Steamship Company.
Anchor Steamship Company.

The Adams Express Company also continues its liberal policy in regard to freight for the Institution.

During the year 2,561 packages, containing many thousand different articles, were transmitted to foreign countries. These packages filled 159 large boxes, having a cubical content of 954 feet, and weighing 26,850 pounds. The parcels received at the Institution for parties in this country, in addition to those for the Smithsonian library, numbered 4,635.

It was mentioned in the last report that the advantages which result from the system of international exchanges had become so apparent that arrangements similar to those adopted by the Smithsonian Institution are beginning to be introduced into different parts of Europe, and that a central scientific bureau for the Netherlands had been established at Amsterdam to receive and transmit packages for different parts of the world, and in the United States to co-operate with the Smithsonian Institution. A similar arrangement has been proposed in

Brussels, by which the Belgian Academy will become a center of scientific exchanges.

During the past year we have received as usual, from persons abroad, copies of works to be distributed gratuitously to institutions and individuals in this country.

The following are the regulations which are to be observed by parties availing themselves of the privilege of the Smithsonian system of exchange:

"The Smithsonian Institution receives parcels at any time with assurance of speedy delivery, at least to the more important addresses, upon the following conditions, which must be strictly observed:

"1. Every package without exception must be enveloped in strong paper, and secured so as to bear separate transportation by express or otherwise.

"2. The address of the institution or individual for whom the parcel is intended must be written legibly on the package, and the name of the sender must be written in one corner.

"3. No single package must exceed the half of a cubic foot in bulk.

"4. A detailed list of addresses of all the parcels sent, with their contents, must accompany them.

"5. No letter or other communication can be allowed in the parcel, excepting such as relates exclusively to the contents of the package.

"6. All packages must be delivered in Washington free of freight and other expenses.

"Unless all these conditions are complied with, the parcels will not be forwarded from the Institution, and, on the failure to comply with the first and second conditions, will be returned to the sender for correction.

"The Institution recommends that every parcel shall contain a blank acknowledgment, to be signed by the recipient and returned, either through the agent of the Institution, or, what is still better, direct by mail, to the sender. Should exchanges be desired for what is sent, the fact should also be explicitly stated on the accompanying circular. Much disappointment has often been expressed at the absence of any return in kind for transmissions; but unless these are specifically asked for they will frequently fail to be made. It will facilitate the labors of the Institution greatly if the number corresponding to the several addresses in the Smithsonian printed catalogue be marked on the face of each parcel; and for this purpose a copy of the work will be forwarded to all who apply for it.

"Specimens of natural history will not be received for transmission, unless with a previous understanding as to their character and bulk."

LIBRARY.

It was stated in the last report that the accessions to the library during 1871 had not been as large as they were the year before, on account of the war in Europe. In 1870 the whole number of books, &c., received was 5,182; in 1871, 4,597; while during 1872 it has been 5,962, as will be seen from the following detailed statement of the books, maps, and charts received by exchange in 1872:

Volumes:		
Octavo or less	975	
Quarto or larger	287	
		1,262
Parts of volumes:		
Octavo or less	1,371	
Quarto or larger	1,250	
		2,621
Pamphlets:		
Octavo or less	1,557	
Quarto or larger	324	
		1,881
Maps and charts		198
Total receipts		5,962

The following are some of the principal donations received in 1872:

From the Commission européenne du Danube, Galatz—"Mémoire sur les travaux d'amélioration exécutés aux embouchures du Danube," with an atlas of 40 plates.

From A. W. Franks, esq., London—"Catalogue of the Collection of Glass," formed by Felix Slade. London, 1871. Folio. Beautifully illustrated.

From the Observatorio do Infante D. Luiz, Lisbon—"Annals." Vols. iii–viii, 1866–1870. Folio.

From the Institut de France, Paris—"Mémoires de l'Académie des sciences." Vols. xxxvi, xxxvii. 4to. "Comptes-rendus." Vols. lxviii–lxx. "Tables Générale," 1851–1865. 4to.

From Dr. K. Keck, Berlin, 203 pamphlets—University Theses.

From the University of Tübingen—"Repertorium morale." Vols. i–iii. 1489. Folio. "Universitätsschriften," 1870; and 18 pamphlets.

From the Universities of Bonn, Erlangen, Giessen, Göttingen, Greifswald, Halle, Heidelberg, Jena, Leipzig, Marburg, Pesth, Bern, Zürich, and Havana—Inaugural Dissertations for 1871.

From the Royal Veterinary Academy, Utrecht—47 pamphlets.

From the University and Government of Chili, Santiago—10 volumes and 2 pamphlets.

From the Public Library of Buenos Ayres—151 volumes, 334 parts of volumes and pamphlets, and 7 charts.

From the Hungarian Academy of Sciences, Pesth—9 volumes and 33 parts of volumes.

From the Royal Public Library, Stuttgart—26 volumes and 11 parts.

From the Hydrographic Department of the Ministry of Marine, St. Petersburg—57 charts, 16 volumes, and 9 parts.

From the Royal Academy of Sciences, &c., Rouen—"Mémoire sur le Commission maritime de Rouen," vols. i and ii; and "Précis analytique," 1804–1870, 14 volumes.

From the Ohio State Library, Columbus—13 volumes and 5 charts.

Among the donations there are two which deserve especial notice, namely, the memoir upon the works which have been executed for the improvement of the mouth of the Danube, and the fac-similes of the Egyptian papyrus.

The first consists of an account, with a large atlas of plates, of the investigations which have been made in regard to the obstruction in the way of navigation of the outlet of the Danube, through several channels along the delta of the river. This subject appears to have been of so much importance that a commission was instituted in accordance with the provisions of the treaty of Paris of 30th March, 1856, including the representatives of seven different powers. The body of the memoir in question gives an extended account of the following subjects: 1. Preliminary investigations and preparatory works; 2. The choice of the mouth to be improved, and an elaboration of a definite project; 3. The provisional work. An appendix presents the report of the chief engineer, Sir Charles Hartley, containing: 1. A general description of the delta of the Danube; 2. The formation of the bars; 3. The means of improving the entrance to the river; 4. A comparison of the different branches; 5. The result of meteorological and technical observations from 1859 to 1865; 6. Statistics relative to commerce and navigation. The memoir is accompanied by a large atlas of 40 double-folio colored plates.

The work is one of great value to the engineers of this country, in reference to the improvements which will doubtless be undertaken in regard to the rivers and water-courses of the United States. To this subject public attention has not been directed with an intensity commensurate with its importance.

If we cast an eye on the map of the United States and view the relation which exists between the vast body of water in the northern lakes and the branches of the Mississippi and the Ohio, we must be struck with the means which nature has placed within the power of man for improving the navigation of the great water-courses which form the channels of communication between the interior of the country and the sea-board.

We have, in a previous report, mentioned the interesting fact that among our correspondents was the Institute of Egypt, founded at Alexandria in 1859. Since then our correspondence with that country has been kept up, and more especially increased during the last year by the visit to that country of one of the members of the Board of Regents, General Sherman. We have received from General Stone, of the Egyptian army, an interesting chart of the fluctuations of the Nile, and from the author, Auguste Mariette Bey, the fac-similes of the Egyptian papyrus in the museum of Boulaq, prepared under the auspices of S. A. Ismail Pacha, Khédive of Egypt. These fac-similes occupy forty-four folio-plates, on tinted paper, representing in color and form the present appearance of the papyrus.

Among the donations to the library should also be mentioned a collection of two thousand drawings of fishes, including copies of all known engravings of fishes published up to 1834, made by Dr. A. Reuss, formerly of Germany, but now of Belleville, Illinois.

WORK DONE IN THE INSTITUTION AND IN CONNECTION WITH OTHER ESTABLISHMENTS.

The Secretary, from the first organization of the Light-House Board, has been one of its members, and has acted as chairman of the committee on experiments. In this capacity he has made in past years an extended series of investigations relative to different materials of illumination, also investigations relative to different instruments proposed for fog-signals, besides reporting on a large number of propositions made to the board with the idea of improving the aids to navigation. During the last year he continued the investigations in regard to fog-signals, and for this purpose spent his last summer's vacation on the coast of Maine. For these services he receives no other compensation than ten cents a mile as traveling expenses. The work is one, however, in which he takes great interest, and it has been to him a source of diversity of employment and a means of improved health.

He has, during the past year, upon the retirement of Admiral Shubrick, been elected chairman of the board.

The Secretary is also one of the visitors to the Government Hospital for the Insane, and as President of the National Academy of Sciences directed the preparation of the instructions for scientific observations for Captain Hall's arctic exploration. In addition to the foregoing, the Government placed the direction of the exploration of Major Powell in charge of the Smithsonian Institution.

Appropriations have been made at the last two sessions of Congress for investigations, under the direction of Professor Baird, of this Institution, relative to the alleged decrease of food-fishes on our coasts. To this at the last session was added an appropriation for stocking the rivers and lakes in the United States with useful fishes. These investigations have occupied all the time and attention he could spare from his duties in connection with the Smithsonian Institution.

Besides the prominent subjects of immediate inquiry, there were quite a number of collateral matters bearing on the general questions, which were prosecuted at the same time, and which have in themselves much scientific interest. His headquarters for the season were fixed at Eastport, on the Bay of Fundy; and, with Professor Verrill to take charge of the invertebrate fauna, he was enabled to gather, both at Eastport and Grand Manan, immense numbers of specimens, which, when fully elaborated, will be distributed to various scientific establishments throughout the world. With the facilities furnished by the Government in authorizing the use of the revenue-cutter Mosswood whenever necessary, the party was enabled to carry on these researches in every branch of the inquiry, including dredging and temperature-observations at great depths in the Bay of Fundy. Every facility was heartily rendered in this work by Captain Hodgdon and his officers. For a portion of the time a detail of the party, consisting of Professor Webster and Mr. C. H. Pond, was occupied at Cape Porpoise, south of Portland, as also at the island of Grand Manan.

By permission of Professor Peirce, the Superintendent of the Coast-Survey, Professor Baird also placed a party on board the Coast-Survey steamer Bache while surveying the Georges Banks and other shoals off the coast of New England; this detail consisting for a time of Mr. S. J. Smith, and Mr. Oscar Harger, of Yale College, and afterward of Dr. A. S. Packard, jr., and Mr. Cook, of Salem.

The additions to our knowledge of the natural history of the American seas made by all these parties has been very great, and the results will be published in detail in the report of the commissioner to be made to Congress.

While engaged at Eastport himself, Professor Baird had a party also at Wood's Hole, the scene of his labors during the year 1871; and several interesting additions to the known fauna of the Vineyard Sound region were made, among them, two genera and species of the sword-fish family, previously unknown on the coast of the United States; and other specimens of marine animals, especially of fishes, were contributed by Mr. Samuel Powell, of Newport.

The following is an account of the work done by Mr. F. B. Meek, who still retains his apartments in the building, and examines and reports to the Institution all specimens of paleontology and geology submitted to it for examination.

Most of his attention during the year 1872 has been devoted to the invertebrate paleontological department of the Ohio State geological survey. The collections have been sent to him at the Smithsonian Institution. He has, from time to time, published preliminary papers on these fossils in the Proceedings of the Academy of Natural Sciences of Philadelphia and the American Journal of Science and Arts, and subsequently prepared more elaborate descriptions for the first volume of the Final Report of the Ohio Geological Survey, in charge of Dr. J. S. Newberry. He has also had the drawings, illustrating his part of this volume of the Report, and a part of those for the second volume, made in the Institution, under his immediate direction; and has likewise arranged the plates and superintended the engraving of the same, so far completed.

In the early part of the year he prepared for publication some notes on the geology of the country immediately about the White Sulphur Springs, of Greenbrier County, West Virginia, with figures and descriptions of a few new fossils. He has likewise superintended the engraving of the quarto-plates of fossils from the Upper Missouri country, illustrating a report on the region, to be published by the Government in connection with the results of the United States Geological Survey of the Territories, in charge of Dr. Hayden.

On account of failing health he was induced to avail himself of an opportunity to spend the summer in the Rocky Mountains and along the Union Pacific Railroad through to the Pacific, during which journey he collected specimens and made observations at the expense of the Government survey. Since his return he has prepared descriptions of some forty or fifty new species of fossils collected during his journey, to be published in Dr. Hayden's report.

METEOROLOGY.

Among the first acts of the Institution was the establishment of a system of meteorology, intended especially to gather trustworthy information as to the character of American storms and the general climatology of the United States. To assist in this enterprise, Mr. James P. Espy was for several years previous to his death associated with the Institution. Lieutenant Maury, then in charge of the Observatory, had previously established a system of meteorology for the sea, and for several years another system had been carried on by the War Department at the various military posts of the United States, besides subordinate systems in the States of New York, Massachusetts, and Pennsylvania.

It was the intention of the Institution to harmonize these different systems, and, as far as possible, to reduce and discuss the results on one general plan. For this purpose it had prepared at its expense, by Professor Guyot, a volume of meteorological tables, also a series of instructions, and introduced a set of trustworthy instruments, constructed by Mr. James Green, of New York.

The Institution was the first to employ the telegraph in the prediction of the weather; but as its income was not sufficient to carry on this operation to its full extent, and owing to the interference of the war, the project was for a while abandoned. The proposition was, however, afterward brought before Congress by other parties, and a system of weather-forecasts established under the direction of the War Department, in the especial charge of Chief Signal-Officer General A. J. Myer.

The placing of this system of forecasts under the War Department gave it special advantages not otherwise to be secured by it. The observers are all enlisted in the Army and paid out of the Army appropriations. The whole being under military discipline gives the system a regularity and efficiency which leaves nothing in this respect to be desired. The appropriation for the support of the system has thus far been very liberal, and I do not doubt it will continue to be so from year to year.

Since the establishment of the Government system of weather-forecasts I have proposed, on the part of the Smithsonian Institution, to abandon the field of meteorology to General Myer, preserving to the Institution only the labor of discussing and reducing all the observations which it has collected from its own observers and from all others in the country up to, say, the year 1872. To this proposition I have not as yet received a reply.

The Smithsonian system includes at present about five hundred observers, who give their services voluntarily. They are of two classes: those who report upon the barometer, thermometer, psychrometer, rain and wind gauges, and those who report upon only the temperature, the wind, the face of the sky, and the rain. Of the first class there are about one hundred and fifty, and these serve as standards to which the observations of the second class are referred. Most of the instruments of the first class have been constructed by Mr. Green. The rain-gauges are of a very simple form, consisting of merely a cylinder of tinned iron, two and a half inches in diameter and twelve inches deep, in which the rain is measured to within half a tenth of an inch by the insertion of a graduated slip of wood.

If the system just described were incorporated with that of the Government, and an agent sent from time to time throughout the country to instruct the observers, the whole would form a more extended and perfect system than any now in existence. The voluntary observers would render good service in supplementing the more precise observations of the Army in marking the extent and boundary of special conditions of the atmosphere and in noting casual phenomena, such as thunder-storms, auroras, tornadoes, &c.

The Smithsonian system has now been in operation more than twenty years, and the Institution is at present occupied in reducing and discussing the observations up to 1870 for publication. The only part of the results as yet published is that relating to the rain-fall. The part relative to the winds will be put to press in the course of a few months. All the observations on the winds which the Institution has been able to collect from unpublished and published records were placed in the hands of Professor J. H. Coffin, of Easton, Pa., who has nearly completed their discussion. Of this discussion of the "winds of the globe," which has been made at the expense of the Institution, excepting as far as the labors of Professor Coffin were concerned, the tables have nearly all been completed, and the preparation of the maps and descriptions alone remains to be done previous to putting the work to press.

All the temperature-observations have been for several years placed in charge of Mr. Charles A. Schott, of the Coast Survey, and are being reduced as rapidly as the appropriation for the purpose from the Smithsonian income will allow. The first division of this work has been completed, and will be sent to press during the coming year. This section consists of tables and discussions necessary to reduce observations taken at different times of the day to the true mean of the day, and other general corrections of irregular observations, and hence it was necessary that this should be prepared first. It includes—

1. General remarks on the explanation and extreme cases of the daily fluctuations of the temperature; investigation of the corrections to the mean temperature from certain hours of the day to refer it to the true mean of the day.

2. Tables of times of sunrise and sunset for every tenth day of the year, and between latitudes 23° and 60°.

3. Applications of Bessel's circular function to represent the daily fluctuation, (yearly average;) the results for twenty stations are given.

4. Classification of the daily fluctuation into six typical forms; epochs of maximum and minimum, and of mean values and daily range, (with two diagrams.)

5. Annual variation in the range of the daily fluctuation, (with two diagrams;) and extremes of daily fluctuation in December and June, (with three diagrams;) also table of recorded daily range of temperature for every month and for certain stations.

6. Variability of the temperature at any hour from the normal value of that hour, specially investigated for Toronto, Mohawk, Philadelphia, and Sitka.

7. Table of the mean values of the hourly, bi-hourly, or semi-hourly observations of temperature, for every month, at nineteen stations.

8. Table of the daily fluctuations of temperature derived from the preceding table, and showing, for every hour and for each month and the year, the difference from the respective daily mean temperature.

Self-registering instruments are absolutely necessary for this kind of investigation, and when their readings are applied will place the results on a more satisfactory footing, and one commensurate with the importance of the subject.

The following is the condition of the work, which has been continued during the past year with the labor of two computers:

1. Consolidated tables, giving the mean temperature for each month, season, and the year, have been prepared for the following States, &c.: Alabama, Alaska, Arizona, Colorado, Dakota, Idaho, Nebraska, West Virginia, Greenland, Iceland, British North America, and part of New York.

2. A large number of observations made at Havana, Cuba, have been computed and added to the general tables. Various other additions have been made and many deficiencies supplied.

3. About three-fourths of the annual means at the different stations have been calculated, embracing about 7,000.

4. The maxima and minima tables have been nearly completed.

MISCELLANEOUS.

At a meeting of the British Association in 1868 a committee was appointed for the purpose of obtaining observations in various localities on the rate of increase of underground temperature downward. This committee (through its secretary, Prof. J. D. Everett) has requested the Institution to furnish observations on this subject from the United States.

These observations are generally made by noting the temperature in artesian wells; and although a large number of these borings for water have been made in this country, the precautions to be taken, and the skill required, in obtaining the true increase of temperature in relation to the depth are of a character not to be intrusted to ordinary observers; and, therefore, to meet the requirements of the committee, a special agent will be necessary to visit the different localities. The income of the Institution, up to this time, has not permitted the incurring of the cost of such an agency, although we hope in the future to be able to make an appropriation for the purpose. In the mean while we have intrusted a set of four standard thermometers, furnished by Professor Everett, and compared at the Kew Observatory, to Mr. B. D. Frost, engineer of the Hoosac Tunnel, Massachusetts.

The investigation is one of great interest to the geologist, being intimately connected with the hypotheses concerning the geological changes to which the globe, has been subjected. The fact has been fully established that, in every part of the world where observations have been made, after descending a few feet below the surface or beyond the depth at which the temperature of the ground is affected by variations in the solar heat, there is a gradual increase of temperature varying in the rate of increase at different places, but on an average not far from one degree in every sixty feet, or a rate which, if continued, would indicate the fusing-point of iron at a depth of about twenty-eight miles.

At the last meeting of the Board the subject of the desirability of the franking privilege to the Institution was discussed, as it had frequently been at previous meetings. Hon. Mr. Hamlin, who is a member of the Post-Office Committee of the Senate, offered to endeavor to procure action of Congress in regard to this object, and accordingly at the last session the following law was enacted.

"All publications sent or received by the Smithsonian Institution, marked on each package 'Smithsonian Exchange,' shall be allowed to pass free in the mail." (New Postal Code, 6th subdiv., 183d sec.)

It will be seen from the above that the franking privilege is confined to printed matter, and does not relieve the Institution from the burden of its large letter-correspondence, and, above all, from a new and unexpected source of expense in the mineral specimens which, since the transfer of the collection of the Land-Office to the museum of the Institution, are sent by mail from the different Government surveyors. We have before us a lot of specimens from one Government officer on which postage of upward of thirty dollars is charged. Unless provision is made for the transmission of these to the Institution through the mails free of cost, as it was in the case of the Land-Office, we shall be obliged to decline receiving them.

By the will of Henrietta Jane Bedford, of Wilmington, Del., daughter of Hon. Gunning Bedford, jr., one of the framers of the Constitution of the United States, aid-de-camp to General Washington, and first district judge of the United States for the district of Delaware under the Constitution, a bequest was made to the Smithsonian Institution of a pair of pocket-pistols, presented to her father by General Washington; also a silver punch-strainer, said to have been made out of a silver dollar earned by Benjamin Franklin on the first day newspapers were carried round the city of Boston for sale. In case these bequests should not be accepted by the Institution, they were to be given to the Historical Society of Delaware.

While the motive which induced this bequest is fully appreciated, the objects, not being of a kind now in its collections, which relate more especially to natural history and anthropology, the Institution preferred that they should be presented to the Historical Society of Delaware.

At the request of the ladies in charge at Mount Vernon it has been thought proper to deposit with them the model of the Bastile of Paris, presented to General Washington; an iron stirrup of a saddle used by Mrs. Washington; and a small picture of Mount Vernon. These articles came into the possession of the Institution from the effects of the National Institute, and can be reclaimed for the National Museum at any time it may be thought important to obtain possession of them.

It was mentioned in the last report that a portion of the large room in the second story of the building was used for the exhibition of the cartoons or original sketches of Indian life, made by the celebrated Indian student, George Catlin. Mr. Catlin continued his exhibition of these pictures during the summer, and devoted all his time not occupied in explaining his pictures to visitors, to finishing the sketches. Unfortunately, in passing between the Institution and his boarding-place, which were separated by the distance of more than a mile, he exposed himself to the heat of the unusually warm summer, and was seized with a malady which terminated his eventful life on the 23d of December, 1872, in the seventy-seventh year of his age.

Since the subject will again come before Congress, I may here repeat what was said in my report last year relative to the purchase by Congress of the Catlin collection: "The entire collection, which comprises about twelve hundred paintings and sketches, was offered by Mr. Catlin to the Government in 1846, and its purchase was advocated by Mr. Webster, Mr. Poinsett, General Cass, and other statesmen, as well as by the principal artists and scholars of the country. A report recommending its purchase was made by the Joint Committee on the Library of Congress, but, owing to the absorption of public attention by the Mexican war, no appropriation was made for the purpose. Mr. Catlin made no further efforts at the time, but exhibited his pictures in Europe, where, on account of an unfortunate speculation into which he was led in London, claims were brought against them which he had not the means to satisfy. At this crisis, fortunately, Mr. Joseph Harrison, of Philadelphia, a gentleman of wealth and patriotism, desiring to save the collection for our country, advanced the means for paying off the claims against the pictures, and shipped them to Philadelphia, where they have since remained unredeemed. Mr. Catlin, however, retained possession of the cartoons, and has since enriched them with a large number of illustrations of the ethnology of South America. Whatever may be thought of these paintings from an artistic point of view, they are certainly of great value as faithful representations of the person, features, manners, customs, implements, superstitions, festivals, and everything which relates to the ethnological characteristics of the primitive inhabitants of our country. We think that there is a general public sentiment in favor of granting the moderate appropriation asked for by Mr. Catlin, and we trust that Congress will not fail to act in accordance with this feeling." It is the only general collection of the kind in existence, and any one who has given thought to the subject could scarcely fail to sympathize with the last anxious feelings of Mr. Catlin that, after a life of devotion to Indian ethnology, these results of his labors might be purchased by the Government. To insure the permanent preservation of the collection, Mr. Catlin would have gladly presented the pictures to the Government as a gift had he not expended all his worldly possessions in the formation of the collection, and therefore had nothing wherewith to redeem the portion of the general collection pledged for debt or to bestow upon his three orphan daughters.

NATIONAL MUSEUM.

Until the year 1870 the support of the National Museum principally devolved on the Smithson fund, only $4,000 having been annually appropriated by Congress for this purpose. Since that date, however, Congress has indicated an intention of providing for the full support of the museum. In 1870 and 1871 it appropriated $10,000, and in 1872, $15,000. This last sum, however, is scarcely yet sufficient to defray the expenses.

The cost of the reconstruction of the building, exclusive of furniture, after the fire of 1865, was $136,000, the whole of which was paid from the Smithson income. This expenditure was for restoring the main building and not for fitting up rooms wanted for the further extension of the museum. For the latter purpose, Congress has made appropriations, since 1870, amounting in all to $35,000. Of these appropriations $20,000 have been expended in ceiling, flooring, plastering, and finishing the great hall, occupying the entire second story of the main building, intended for the extension of the museum; and, with the remainder of the appropriation, arrangements have been made for furnishing with cases this room, and also the room formerly occupied by the library, and now devoted to mineralogy and geology.

With a view to the entire separation of the affairs of the museum from those of the Smithsonian proper, all the operations of the latter, with the exception of those in the Regents' room, are carried on in the east wing and range of the building, leaving all the other parts, including the main edifice, towers, west wing, and west range, to the museum

The following is Professor Baird's account of the additions to the Museum, and the various operations connected with it during 1872:

Additions to the National Museum in 1872, *in geographical sequence.*—The additions to the National Museum, in charge of the Smithsonian Institution, during the year have shown a gratifying increase over those of 1871, and have been decidedly equal in value to those of any previous year. The great bulk, as might be expected, has been derived from the collections of the various Government expeditions, especially those under the charge of Professor Hayden, Professor Powell, and Lieutenant Wheeler, supplemented, however, by others, contributed by private effort, especially on the part of Mr. Henry W. Elliot and Mr. William H. Dall.

A great addition to the magnitude of a portion of the cabinet, namely, that of mineralogy and geology, has been the result of the transfer to the Institution, under the order of the Secretary of the Interior, of the extensive museum of the Land-Office.

In the appendix to this report will be found a detailed list of the donors of the various specimens, together with the general indication of their nature; but with a view of calling attention more particularly to the different regions represented therein, I beg leave to present some remarks, both in regard to the auspices under which they were secured and their general character.

As in previous years, the principal regions of America are more or less represented among the additions in 1872, and these, as usual, will be mentioned in systematic order.

Beginning, therefore, with the Northwest Coast, we have, in the first place, from the Island of Saint Paul, one of the fur-seal group in Behring Sea, a very extensive collection, presented by Mr. Henry W. Elliot, for a long time connected with the Institution. This gentleman visited the two seal-islands, Saint Paul and Saint George, as an assistant agent of the Treasury Department, to attend to the interests of the Government with the Alaska Commercial Company, and to look after the welfare of the native tribes. The collection embraces a large number of skeletons of many species of water-fowl, as well as their skins and eggs, quite a number of which are new to the national collection; also various fish, mollusca, and other marine objects, together with minerals, rocks, and plants.

Mr. William H. Dall also contributed largely from the region a little to the south of that occupied by Mr. Elliot, namely, Unalaska and some adjacent islands. The most marked feature of Mr. Dall's contribution consists in the rich collections of pre-historic objects, some of them found in localities of which the native Aleuts have no tradition as being the site of ancient settlements. The series is of interest, as showing the state of civilization among the progenitors of these people. Other objects collected by Mr. Dall consist of marine invertebrates, fishes, and numerous birds, eggs, &c. Among the eggs are several new kinds, which, with the contributions by Mr. Elliot, nearly complete the desiderata of the National Museum in regard to the water-birds of the North Pacific.

Some contributions have also been obtained from Professor Harrington, the companion of Mr. Dall. It should be stated that Mr. Dall has been engaged since July, 1871, in the service of the Coast Survey, in surveying the Aleutian Islands, and that the collections made by him, like those of Mr. Elliot, were gathered entirely at his own expense, at such periods as could not be occupied by any regular official work. In addition to the specimens just named, skulls of rare species of cetaceans were supplied by Captain Scammon, who has also added to them others from Southern California.

From Oregon have been received several series of Indian relics, and a number of human and other crania, presented by Mr. Bissell.

California has furnished some curious remains of fossil vertebrates from Point Conception, presented by Mr. Sceva, and collections of Sacramento *salmonidæ* from Mr. Stone. Dr. L. G. Yates has continued his contributions of ancient relics, as also of minerals and fossil remains. Some rare birds' eggs and nests have been furnished by Mr. William A. Cooper, of Santa Cruz.

From the States and Territories in the interior of North America, especially those of the Great Basin and of the Rocky Mountain region, the collections have been principally made on the part of the Government expeditions, nearly all of which have had the center of their operations within these boundaries. Among these we may mention, first, the parties of Professor Hayden, who renewed in 1872 his explorations of 1871 in the Geyser basins of the Upper Yellowstone, as also farther to the west, in the regions between Fort Hall and the Three Tétons.

In addition to the researches prosecuted by his own immediate party, and its division under charge of Mr. Stevenson, with Professor F. H. Bradley as geologist, there were several subsidiary explorations prosecuted in connection with Dr. Hayden's labors, by Professor Joseph Leidy in Wyoming, and by Professors Meek and Bannister, Professor Lesquereux, and Professor E. D. Cope, all of whom added largely to the general collections, the total number of boxes of specimens received from Professor Hayden's expedition amounting to very nearly one hundred.

The labors of Lieutenant Wheeler in the more southern portions of the region referred to were continued throughout the season, with Messrs. Gilbert and Howell as geologists, Dr. Yarrow as surgeon and chief naturalist, Mr. Henshaw as assistant naturalist, and Mr. Severance as ethnologist. The investigations of these gentlemen were prosecuted in Southern Utah and in Eastern Nevada, and resulted in the acquisition of rich collections of geological specimens, as also of a large series of animals, especially of the vertebrates. The ethnological contributions of the party were also of much interest.

Professor Powell also, in continuation of preceding explorations along the Colorado River, devoted himself more particularly to the collection of Indian remains, and succeeded in procuring a very extensive series of everything illustrating the habits and manners of the interesting tribes that now occupy that region.

From Governor Arny, of New Mexico, the museum has received some valuable minerals, and numerous articles of dress and ornament of the Apaches and other modern tribes. He has also contributed the remains of what Dr. Leidy considers to be a new species of American fossil elephant, and other bones of the same species were supplied by General J. H. Carleton.

Some interesting reptiles of New Mexico were contributed by Dr. Bailey. Other collections of less extent will be found mentioned in the table of list of contributions.

From the valley of the Mississippi have been received human remains from the mounds of Dakota, contributed by General Thomas; from Louisiana and Mississippi, casts of some very remarkable stone implements, furnished by Professor Joseph Jones, of New Orleans; and also original flint objects, together with insects, from Mr. Keenan.

Mr. J. G. Henderson has lent us the rarities of his fine ethnological collection, gathered principally in Illinois, with permission to duplicate them by means of casts; while from Mr. Peters, of Kentucky, Mr. Anderson, of Ohio, and other gentlemen, additions have also been made to the ethnological department.

From the chain of lakes extensive contributions in the way of food-fishes have been furnished by various parties. Among them may be mentioned, as the most important contributor, Mr. J. W. Milner, deputy commissioner of fish and fisheries for the lakes. His transmissions embrace the different species of trout and white-fish in great variety.

In obedience to the instructions of the minister of marine and fisheries of Canada, the fish-wardens on the lakes have also supplied specimens of trout and white-fish from Lake Erie, Lake Ontario, Lake Champlain, the Saint John's River, &c. These have been received from Messrs. Kerr, Kiel, Macfie, and others.

The State of Maine is very amply represented in the collections of the year by means of the specimens of marine animals collected by Professor Baird as United States commissioner of fish and fisheries, and his assistants and associates. In addition to the collections made on the coast of Maine, the Institution has received, through the commissioner of fish and fisheries, a valuable series of the salmon of the Penobscot River from Mr. Atkins; of the blue-backed trout of the Rangely Lakes from Mr. Stanley; and lake-trout and land-locked salmon of the Saint Croix from Senator Edmunds. Marine animals in great variety and of much interest were also collected for the fishery commission at Fort Macon, North Carolina, by Dr. H. C. Yarrow, assistant surgeon of the United States Army, supplemented by others from Dr. Mackie.

The donations from the interior of the Atlantic coast States consisted of Indian relics from Mr. Kellogg, of Connecticut; minerals and rocks of South Carolina from Mr. Waldo; and various specimens of birds from Florida from Mr. George A. Boardman. The trustees of the Charleston College have been kind enough to lend to the Smithsonian Institution, to be copied in plaster, several unique objects of ethnology.

Proceeding to the regions south of the United States, we may mention, first, contributions from the Isthmus of Tehuantepec, furnished by Professor Sumichrast, these consisting of numerous birds and reptiles, a continuation of similar collections previously transmitted. Mr. Florentin Sartorius, of Vera Cruz, also furnished specimens of the rare and curious wax-producing insects first described as *Lystra cerifera*.

From Guatemala have been received collections of insects, presented by Mr. F. Sarg, and from Nicaragua a collection of rare pottery, by Dr. Earl Flint. Certain collections made several years ago by Dr. Berendt near Belize were received during the year, consisting principally of reptiles and shells. As these were gathered at the expense of the several contributors to a common fund, they were assigned for distribution to Mr. Thomas Bland, and Professor Cope.

Of South American regions, New Granada is represented by a collection of birds presented by the American minister at Bogota, Mr. Hurlbut; Southern Brazil by the skeleton of a tapir from Mr. Albuquerque; and Chili by a very valuable collection of native minerals from the University of Santiago, through Professor Domeyko, and a collection of Chilian eggs of great interest from the national museum, through Dr. Philippi.

Perhaps the most interesting South American object is a human head prepared by the Jivaro Indians of the province of Chimborazo, Peru, and presented to the Smithsonian Institution by Don Edward de Feiger, through the honorable Rumsey Wing, United States minister to Ecuador. This head belongs to a very rare series of ethnological objects, of which a very few only have been brought to Europe and America. They are held by their owners in much veneration, and jealously guarded as household divinities. They are believed to be trophies of victories; the head of an enemy being thus prepared for permanent preservation. The precise method of manipulation is unknown, but is supposed to consist in the careful extraction of the bones, flesh, and brains of the head, and the subsequent contracting of the skin by some astringent. The result is a well formed and quite symmetrical head, about four inches in diameter; all parts contracted in equal proportion, and with long flowing black hair; a braid of strings is passed through the lips, and there are several other artificial appendages.

Prof. William M. Gabb has kindly presented to the National Museum some extremely rare and remarkable stone implements and pottery from San Domingo, while Professor Poey, the eminent and veteran naturalist of Havana, has supplied a series of fishes from Cuba as types of his species.

Fishes of Bermuda were also received from Mr. J. Brown Goode.

The collections from other parts of the world, as might naturally have been expected, have not been so great, either in number or value, as those already referred to, although some of them are very important, as tending to complete the series already in the museum. The most interesting of these objects are certain pre-historic stone implements, especially of the drift-period, presented by Mr. William Blackmore, of England, and a similar collection furnished by Mr. Baker.

Professor Holst, of Christiania, has supplied a series of minerals from Konigsberg, a mining-region near that city, while Dr. Sars and Dr. Boeck have furnished specimens of the crustacea, Mr. Robert Collett of the fishes, and Dr. William Boeck a skeleton of *Hyperoodon*. Dr. Möbius, of Kiel, has also sent us a series of the food-fishes and crustaceans from the vicinity of Kiel.

No collections are recorded from Africa, with the exception of a superb skull of the Koodoo antelope, from Captain Holmes. From Japan, however, have been received some remarkable stone and bronze implements of pre-historic times, presented by the Japanese minister, Mr. Mori.

The Sandwich Islands are represented by collections of skulls and ethnology, from Mr. Valdemar Knudsen.

Systematic summary. The preceding enumeration expresses the geographical relations of the collections received during the year; and it may be well, in addition, to make a brief systematic reference to the principal objects received, so far as this has not already been done, especially as some general collections, covering a wide range of country, have not yet been referred to.

The department of ethnology has been especially enriched, not only by the collections of Professor Powell, Mr. Dall, Professor Hayden, and others, but very largely by a contribution from Mr. Vincent Colyer. This gentleman, while connected with the Board of Indian Commissioners, took occasion during his official visits in various parts of the Indian country to collect, at his own expense, large numbers of objects, all of which are now in possession of the Institution.

The head of the mummy, presented by Don Edward de Feiger, already referred to, is perhaps the most important of the ethnological series, but there are other objects of very great interest worthy of note. Among them, one of special interest, is an Indian pipe of black stone, carved in a very striking likeness of a loon, found in West Virginia and presented by Rev. J. N. Davis.

In the department of mineralogy and geology, the additions brought in by the parties of Lieutenant Wheeler and Professor Hayden have been especially rich; the donation of Chilian minerals by Professor Domeyko and of Norwegian by Dr. Holst, will do much to increase the value of this portion of the collection.

The most important addition, however, is that of the Land-Office collection of minerals, embracing many thousands of specimens, and especially rich in series of ores from Nevada, Arizona, Utah, Colorado, and California. These collections will shortly be arranged with others of the same character in the new mineralogical hall.

In the department of zoology, a contribution from the Imperial Zoological Museum of Vienna, of skeletons of large mammals, such as those of the lion, tiger, giraffe, brown bear, &c., may be considered as chief in value. The skeleton of the Brazilian tapir, from Mr. Albuquerque, is also of much moment, as rendering the collection of American tapirs nearly complete. We previously possessed skeletons of the tapir of the Andes from Mr. Hurlbut, the Panama tapir from Captain Dow, and the Guatemala tapir from Mr. Henry Hague; the last additions making skeletons of four perfectly distinct species or varieties of this animal.

The skeletons and skulls of the cetaceans of the west coast from Captain Scammon, a skeleton of hyperoodon whale from Dr. Boeck, and skeletons of many hundreds of birds from Henry W. Elliot may also be enumerated.

Among mammals, the chief accessions have been that of a Rocky Mountain goat, from W. J. Wheeler, since mounted and placed in the collection; that of a gnu from an unknown source, and the restoration in full size of the Irish elk, deposited by Mr. Waterhouse Hawkins.

The Royal College of Surgeons of London has contributed a collection of casts of the brains of mammals.

Of birds, a valued addition is that of the rare Labrador duck from the Museum of Natural History of New York; and the extensive collections of Professor Hayden, of Lieutenant Wheeler, of Mr. Dall, and of Mr. Henry Elliot embrace many important specimens. The eggs from Messrs. Dall and Elliot, taken in Alaska, and those from Chili, are of principal value.

The collection of fishes has been very large, made principally by or on behalf of the commission of fish and fisheries. It embraces specimens of the *Salmonidæ* of the Sacramento River, received from Mr

Livingston Stone, and of various localities on the great lakes, and in the States of Maine and New Hampshire.

The marine collections from the coast of Maine, Vineyard Sound, Rhode Island, Fort Macon, Cuba, and the Bermudas have already been referred to. The European collection presented by Messrs. Sars, Boeck, and Collett, as also those of Dr. Möbius, of Kiel, will also be of much value for purposes of comparison.

The invertebrates gathered under similar auspices have also been very numerous, and will furnish ample means for distribution to other museums.

In accordance with the policy of the Institution, all the specimens of human anatomy, including crania and skeletons from the ancient mounds, have been turned over as soon as received to the Army Medical Museum, while the insects and the plants have, in like manner, been deposited with the Agricultural Department.

The total number of distinct donations received during the year 1872 amounted to 315 entries, comprising 544 separate packages and coming from 203 different donors.

The corresponding figures for the year 1871, consist of 271 donations, comprising 400 packages.

Work done in the museum.—The addition of so large a stock of material to the collections already in charge of the Institution, of course, involved a great deal of labor, such as the unpacking and classifying of the objects; the labeling of all, at least as to localities; the entering in their respective record-books; the putting such of them in order as required it; placing such as were ready for immediate exhibition on their respective shelves; and storing the rest away where they could most readily be referred to on occasion.

All dry objects of an animal nature generally need prompt attention to prevent their being affected by mold or by the attacks of insects; ethnological objects usually requiring to be thoroughly cleaned and poisoned, while skins of animals, furs, Indian robes, dresses, &c., must be immersed in some poisonous solution before they can be considered as permanently secure. All this has been effected with as much thoroughness as the time and force at the command of the Institution would permit.

In addition to this, it was found that the immense collection of objects of dresses and ornaments belonging to the ethnological galleries, were more or less infected by moths, and it became necessary to subject the entire series to a process of renovation, embracing many thousands of specimens.

The transfer of the mounted birds and mammals from the old stands to those of a neater form has also been prosecuted to a considerable extent during the year, several thousands having been so treated, to the manifest improvement of the general appearance.

Perhaps the most important labors in the museum have been that connected with the renovation of the extensive alcoholic collections. These were in a very unsatisfactory condition, in consequence of the fire of 1865, and the unavoidable confusion during the process of reconstruction of the various apartments of the Institution.

The bottles were necessarily stored in a damp cellar, where the labels became obliterated to a greater or less degree; and although the precaution had been taken to introduce within the jars numbers corresponding to those of the external label, yet both in many cases were found to have become illegible. It was necessary, therefore, to use every effort to remedy the difficulty by re-labeling such specimens as had not lost their history beyond recovery; and this work has occupied a considerable portion of the force the entire year. All the bottles, however, have been cleaned and placed in a dry cellar, and during the coming year this part of the collection will be put in as good order as can be desired.

A considerable portion of the time of the employés of the museum was occupied in the transfer of the extensive collection of rocks and minerals from the Land-Office, which has necessarily required great care to prevent the misplacement of the labels. This was, however, satisfactorily accomplished, and the specimens are now safely in the possession of the Institution, and, it is hoped, will be placed on their shelves in the course of the year 1873.

Quite a number of the skeletons of the larger animals, such as the Irish elk, several species of tapir, the American moose, the buffalo, American and European bisons, the elk, camel, &c., have been mounted during the year and placed in the general collection. There is yet much to be done in this direction, the museum fortunately possessing very complete series of the bones of most of the American mammalia and many foreign species. Several large mammals have also been mounted, such as the bison, the moose, walrus, and a considerable number of the larger fish found on the Atlantic coast.

Distribution of specimens.—In accordance with the policy adopted by the Smithsonian Institution in the administration of the collections of the National Museum, much has been done in the way of transmission of specimens to other museums at home and abroad.

Many of the rare and more choice stone implements in different museums throughout the country have been borrowed and duplicated by means of casts, and enough of these prepared to permit quite an extensive distribution.

The collections brought in by Professor Hayden during his different expeditions of several years past were all unpacked and arranged; and after reserving a series for the Museum of the Institution, the remainder were made up into some fifteen or twenty sets, which were distributed to different colleges and academies throughout the country. This branch of the work of the Institution, it is hoped, can be greatly extended during the coming year, in view of the immense number of duplicates which will be found in the Land-Office collection and in the collections just received from the various Government expeditions.

A large number of specimens in mineralogy and geology were also boxed up and transmitted to Professor Egleston and Professor Newberry, of the School of Mines in New York, under the existing arrangement with those gentlemen to select and label a perfect single series for the National Museum and to exchange the duplicate specimens in its interest. Numerous returns have already been received of valuable material, adding greatly to the richness of the lithological department.

Dr. Coues, assistant surgeon in the Army, having volunteered to prepare a monograph of the smaller rodents of North America for publication by the Institution, received at Baltimore the entire collection of specimens, both in alcohol and in skins. Having subjected these to a careful criticism, he made the duplicates into thirty sets, which will be distributed in the course of the coming year to the different museums in this country and Europe, in return for which we shall doubtless receive some valuable additions to the cabinet.

A few of the small number remaining on hand of sets of minerals, geological specimens, shells, &c., have been sent out to various addresses, and as also several series of birds, &c., mammals, skeletons, eggs, &c. The entire number of specimens thus sent forth will be found in an accompanying table.

The museum may now be considered as in much better condition than it has ever been before. The process of renovation is progressing as rapidly as possible, and will, before long, be completed. The establishment of better store-rooms in which to keep the unmounted skins of animals, and the alcoholic collections, has enabled us to work to much better advantage. As fast as each department can be re-organized and placed in a satisfactory condition, pains will be taken to eliminate the duplicates, and distribute them as authorized. The result will be to greatly reduce the bulk of crude material to be cared for by the Institution, and to render a great service to the cause of scientific instruction by disseminating authentically-labeled types of the various species. Returns of great value may be expected also for these specimens.

There is, however, a great deal to be done before the collections at present in the National Museum may be considered as finally arranged, to say nothing of those yet to be received. The greater portion of the ethnological museum will need to be properly mounted on tablets, or otherwise prepared for permanent exhibition, and labeled. As soon as the cases in the large hall of the Institution can be completed, these specimens will be placed in position. It is intended to prepare a large number of effigies representing accurately the lineaments, dress, and form of the tribes of Indians, and to place upon these their corresponding ornaments, weapons, &c.; and to introduce them, either singly or in groups, into suitable cases, where they can most readily be seen.

The approach to completion of the new cases for the mineralogical hall, formerly occupied by the library, makes it necessary to re-arrange all the mineralogical and geological specimens, these including not only such as have been for a long time in the Institution, but the newly-acquired treasures from the Land-Office, and the Government expeditions of 1872. These transfers will vacate a portion of the present exhibition-room, amounting, perhaps, to nearly one-third its present capacity; and it is proposed to occupy the gaps thus made by specimens of mammals, birds, and skeletons. Of these there are ample series in the building, enough, indeed, to fill several large rooms. Such a selection will be made from these as will make up the most important deficiencies in the mounted series at present on exhibition.

Mineralogical collection.—Under the authorization of the Secretary of the Interior, the Commissioner of the Land-Office transferred to the care of the Institution, as a part of the National Museum, the collection of minerals which had been formed by Mr. Joseph Wilson, the previous Commissioner. This collection, intended to illustrate the mineral resources of the country, consisted of samples of ores and geological specimens from every State and Territory in the Union. Though a very valuable addition to the Museum, it is formed in some degree of duplicates of specimens already in the Institution. This fact, however, will enable us to make up sets of duplicates for distribution to colleges and academies. It is proposed to continue the plan inaugurated by Mr. Wilson, of illustrating the mineral products of all parts of the United States in addition to a general systematic mineralogical cabinet. For the exhibition of the latter the large room formerly occupied by the library will be devoted, while the connecting range, by a few changes, will serve as the receptacle for the specimens to illustrate the former.

In concluding the history of the Institution up to the year 1872, it will be evident that the establishment has had, on the whole, a successful career, although it has not been free from mishaps, and the appropriation of the fund was not at first as conformable to the strict interpretation of the will of the founder as could have been wished, yet continued improvement has been made in this respect from year to year. Not only the state of the funds, but the character which the Institution has established over the world, will enable it to compare favorably with the management of any endowment with which we are at present acquainted.

Respectfully submitted.

JOSEPH HENRY,
Secretary Smithsonian Institution.

WASHINGTON, *February*, 1873

NOTES RELATIVE TO GEORGE CATLIN.

George Catlin was born in Wilkesbarre, in the valley of Wyoming, Pennsylvania, in the year 1796. His father was a lawyer of considerable reputation, and designed his son to practice the same profession, which he did for a short time; but his natural inclination for art was so strong that after two or three years he abandoned the idea of becoming a lawyer and removed to Philadelphia, where he pursued his occupation principally as a portrait-painter. It was here that an incident occurred which determined that future career which has made his life and labors famous. A party of roving Indians visiting Philadelphia, decorated with the barbaric splendor of their native dresses, by their bold and martial bearing, and by their unconstrained attitudes and gestures, so impressed him that he determined to become the historian of this remarkable race, which was rapidly becoming extinct, and to devote himself to the illustration of their arts, types, manners, and customs.

With this purpose in view, in 1830 and 1831, he accompanied Governor Clarke, of Saint Louis, then superintendent of Indian Affairs, who was engaged in making treaties with the Winnebagoes, Monomonees, Shawnees, and Sacs and Foxes. In 1832 he ascended the Missouri, on the steamer Yellowstone, to Fort Union, and afterward returned, in a canoe, with two companions, a distance of 2,000 miles, visiting and painting all the tribes, so numerous at that time, on the whole length of the river. The next year he went up the Platte as far as Fort Laramie, and extended his journey to Great Salt Lake. In 1834 he explored the Mississippi as far as the Falls of Saint Anthony, and visited the Ojibbeways and other tribes, and returned to Saint Louis, a distance of 900 miles, in a bark canoe. In 1835 he made a second visit to the Falls of Saint Anthony, and thence proceeded to the Red Pipestone region on the Couteau des Prairies, and then, returning to the Falls of Saint Anthony, descended the river a second time in a canoe to Saint Louis. In 1836 he accompanied Colonel Dodge on an expedition to the Comanches and other southwestern tribes; and in 1837 visited Florida for the purpose of painting the Seminoles and Euchees. During these eight years he visited fifty different tribes of North American Indians, taking sketches all the time. Having thus accumulated a large number of paintings representing the portraits of the principal men and the tribes and the pictures of savage life, he exhibited them in various parts of the United States, especially in Washington, Philadelphia, New York, and Boston, with such success that, in 1839, he went to London and Paris, where the artist and his collections attracted general attention. From this time until 1852 he remained in Europe, being everywhere treated

distinction. In 1852, when fifty-six years old, his enthusi-
[illegible] by his advancing age, and with a vigor and endurance
even in the young men of our day, he explored, with the
the forests of South America. He went to Venezuela, and
the Orinoco, Amazon, and Essequibo, taking a great number of
on his route. He afterward crossed the continent to Lima,
northward visited the mouth of the Columbia River, Nootka
Alaska, and to The Dalles, and up the Columbia River to Walla-
up to the Salmon River Valley, and across the mountains
Snake River Valley at Fort Hall, thenc
Snake River, and returning to Portland p
San Diego. From San Diego he crosse
the Rocky Mountains, and descended t
to Matamoras. From Matamoras he
proceeded to Havre. Starting a
the same year, 1855, he went to Rio
ascending the Paraguay and Parana, he
mountains to the head-waters of the Urugu
the mouth of the Rio Negro and returned to
in 1856, he took passage in a sailing-
of Patagonia, and then north to Pana
in Venezuela, to Santa Martha and
completing his Indian studies, he reti
and brush, again set himself to recordin
to his history of the North American
South America. He remained at Bruss
country in 1871.

During his life, and in periods of rest fror
published the following works:

1. Catlin's Notes of Eight Years' Travels a
Indians, 2 vols., 1851.
2. Catlin's Notes of Eight Years' Residenc
3. Catlin's North American Portfolio, 1844.
4. Okee-pa, a Religious "Mandan" Ceremo
5. Life among the Indians, (book for youth
6. Last Rambles among the Indians of the Rocky Mountains and
Andes, 1867.
7. Shut Your Mouth, 1869.
8. Uplifted and Subsided Rocks of America, 1870.

Terzaroli, Danilo, 1917-
Briciole di pensieri : liriche vincitrici di premi internazionali e italiani / Danilo Terzaroli. — [s.l. : s.n., 1975] (Terni : Soc. Arti grafiche Nobili)
49 p. ; 21 cm.
L1500
I. Title
PQ4880.E607B7
Library of Congress
76-479655
MARC

APPENDIX TO THE REPORT OF THE SECRETARY.

Table showing the number of entries in the record-books of the Smithsonian Museum at the close of the years 1871 *and* 1872, *respectively.*

Class.	1871.	1872.
Skeletons and skulls	12,059	12,450
Mammals	9,849	11,195
Birds	61,250	62,718
Reptiles	7,536	8,729
Fishes	7,983	9,758
Eggs of birds	15,986	16,322
Crustaceans	1,287	2,187
Mollusks	24,792	24,792
Radiates	2,730	3,107
Annelids	100	100
Fossils	7,697	7,715
Minerals	7,160	7,167
Ethnological specimens	10,931	11,607
Total	169,360	177,747

Increase for 1872, 8,387.

Approximate table of distribution of duplicate specimens to the end of 1872.

Class.	Distribution to the end of 1871.		Distribution during 1872.		Total to end of 1872.	
	Species.	Specimens.	Species.	Specimens.	Species.	Specimens.
Skeletons and skulls	325	827	19	37	344	864
Mammals	941	1,822	22	68	963	1,890
Birds	22,940	35,428	1,129	1,667	24,069	37,095
Reptiles	1,841	2,970	....	....	1,841	2,970
Fishes	2,477	5,311	40	87	2,517	5,398
Eggs of birds	6,606	16,698	21	22	6,627	16,720
Shells	83,712	186,157	905	1,035	84,617	187,192
Crustaceans	1,078	2,650	....	....	1,078	2,650
Radiates	583	778	....	....	583	778
Other marine invertebrates	1,838	5,152	6	8	1,844	5,160
Plants & packages of seeds	18,503	25,063	1,867	4,642	20,370	29,705
Fossils	4,109	10,135	3	6	4,112	10,141
Minerals and rocks	4,630	9,974	683	728	5,313	10,702
Ethnological specimens	1,295	1,342	381	397	1,676	1,739
Insects	1,836	3,150	412	1,144	2,248	4,294
Diatomaceous earths	29	623	29	29	58	662
Total	152,743	308,080	5,517	9,880	158,260	317,960

ADDITIONS TO THE COLLECTIONS OF THE SMITHSONIAN INSTITUTION IN 1872.

Abell, J. Ralls. Indian relics, insects, &c., from Virginia.

Akhurst, J. Specimens from Northwest Coast.

Albuquerque, F. Skeleton of Tapir and head of Deer from Brazil.

Allen, J. A., for *Mus. of Comp. Zool., Cambridge, Mass.* Specimen of *Lagomys* in alcohol, and nest and egg of *Plectrophanes ornatus.*

Two specimens *Leucosticte tephrocotis* from Colorado.

Aman, S. Specimen of Spider-crab from Chesapeake Bay.

American Museum of Nat. History, New York. Mounted specimen of Labrador Duck, (*Camptolaemus labradorius.*)

Anderson, Wm. Ethnological specimens and fossils from Ohio.

Arny, Hon. W. F. M. Bundle of arrows of White Mountain Apaches, Arizona, and many other specimens of Ethnology, Mineralogy, and Natural History.

Atkins, C. G. Two specimens of Salmon, from Bucksport, Me.

Aubin, N. Copper-ores from Lake Superior.

Babcock, Gen. O. E. Specimens of silicified wood from excavations of public works, Washington, D. C.

Bailey, Dr G. W. One bottle alcoholic reptiles, insects, &c., from New Mexico.

Baird, Prof. S. F., U. S. Commiss'r of Fisheries. Forty-four boxes general collections from Eastport, Me.

Embryonic chicken in alcohol, Washington, D. C.

Baker, W. A. Collection of prehistoric flint implements from Great Britain.

Barnes, Thos., through *Col. E. Jewett.* Copper chisel from Niagara Co., N. Y.

Bendire, Lt. U. S. A. Birds dried in the flesh, nests, and eggs, from Arizona.

Berendt, Dr. H. Three boxes and one package general collections from Honduras.

Binckley, J. M. Indian stone implement from Virginia.

Bissell, Geo. P. Stone implements, and antler imbedded in wood, from Creswell, Oregon.

Blackmore, W. Prehistoric stone relics from Europe.

Blakeslee, D. Indian stone relics from Ohio.

Bloom, F. J. Fossils and Indian relics from Mississippi.

Boeck, Axel. Crustaceans from Norway.

Boles, Hon. T. S. Specimens of iron-ore from Arkansas.

Brevoort, J. Carson. Specimen of Ring-tailed Monkey from the Amazon, (fresh).

Brown, Dr. Ryland T. Specimens of rock-salt from Arizona.

Brown, Hon. S. G. Quartz arrow-head from Anacostia, D. C.

Brush, A. P. Indian stone implements from Quincy, Pa.

Bryan, *O. N.* Skull of a mound-builder, from mound near Dubuque, Iowa.

Carleton, *Rev. Hiram.* Specimens of wheat prepared against rust.

Carleton, *Gen. J. H.* One box fossil bones from Sonora, Mex.

Choate, *J. B.* One box fossils from Iowa and Illinois.

Clarke, *Geo.* Fishes from Lake Erie and Detroit River.

Clarke, *S. C.* Ethnological specimens from Spruce Creek, Fla.

Cleburne, *Wm.* Three boxes fossils from along the line of Union Pacific Railroad.

Clements, *C. C.*, *Surveyor-General of Utah.* Specimens of silver-ores.

Cochrane, *J.* Ancient pottery, &c., from Illinois.

Cogswell, *Mrs. W. F.* Specimens of iron-ores from Lake Superior.

Collett, *Robert.* Collection of Norwegian fishes.

Colyer, *Vincent.* Indian clothing, implements, &c., from Alaska and the western Territories.

Comstock, *Gen.*, *U. S. A.* Specimens of dredgings made under the lake survey in Lake Superior.

Cooper, *W. A.* Birds' eggs from Santa Cruz, Cal.

Coues, *Dr. Elliott*, *U. S. A.* Skeleton and odd bones of *Didelphys virginianus*, (types of his monograph of the species.)

Curtis, *R. C.* Fossils from Genesee Co., N. Y.

Curtis, *W. W.* Specimens of quartz from Wisconsin.

Cusick, *C. C.* Ethnological specimens from Dakota Territory.

Dall, *W. H.* General collections from Alaska and the Aleutian Islands, part of the collections by M. W. Harrington.

Davis, *Rev. J. H.* Indian stone pipe, (loon shape,) from West Virginia.

Dennis, *Joel M.* Ancient pottery from Newark, Ohio.

Dobson, *J. R.* Specimens of iron and iron-ores from Pennsylvania.

Domeyko, *Dr. Ignacio*, *University of Chili.* Eight boxes of Chilian min erals.

Duvall, *Geo. W.* Specimen of Cormorant, (*Graculus dilophus.*) Sucking-fish, and woodchuck, from Annapolis, Md.

Dyer, *C. B.* Box of fossils from Cincinnati, Ohio.

Edwards, *Amory.* Fossils from Kansas.

Edwards, *Vinal H.* Fishes, &c., from Vineyard Sound, Mass.

Elias, *Mr.* Medal issued in commemoration of the introduction of water into the city of Buenos Ayres, South America.

Elliott, *Henry W.* Ten boxes general collections from Saint Paul's Island, Alaska.

Faulkner, *J.* Collection of birds' eggs from Northern Illinois.

Feiger, *Don Ramon.* Prepared head of Indian from Ecuador, South America, (through Hon. Rumsey Wing, United States minister.)

Fithie, *Jas. S.* Insects, &c., from Mississippi.

Flint, *Dr. Earl.* One box of ancient pottery from Nicaragua.

Gabb, *Prof. W. M.* One box stone implements and pottery from Santo Domingo.

Gibbon, Lardner. Arrow-heads and Indian relics from South Carolina.

Giles, Norwood. Birds' eggs and nests from North Carolina.

Gilpin, Dr. J. B. Specimens of Sea-Trout from Labrador and fishes from Nova Scotia.

Goldsmith, Dr. through *P. S. Phelps.* One box fish from Ticonderoga, Lake Champlain.

Goode, G. Brown. One box fishes from Bermuda.

Greene, A. R. One package minerals and one can fish from Maine.

Griffith, T. D. Cotton raised by Indians of Chickasaw Nation, Indian Territory.

Hamilton, Hon. C. L. Specimen of white Coral from Key West, Fla.

Hansen, F. Walter. One ancient implement of polished iron-ore from Texas.

Harenbergh, J. R., U. S. Survey'r-Gen'l. Specimens of ores from Calaveras Co., Cal.

Harford, G. One box of birds from San Miguel Island, California.

Harris, Wyatt. Fossil univalve from Mt. Vernon, Mo.

Hawkins, B. Waterhouse. Model of Irish Elk (restored) on deposit.

Hayden, Dr. F. V. General collections of minerals, fossils, and specimens of Natural History from Wyoming, Utah, and Montana.

Hatch, Dr. Four specimens of Silver Trout, from Centre Pond, Dublin, N. H.

Henderson, Jno. G. Indian stone implements from mound near Naples, Ill., (loaned.)

Hicks, W. R. One package Indian relics from North Carolina.

Hilgert, H. Specimens of silicified wood from New Mexico.

Hobbs, Maj. T. J. Specimen of Potomac Black Bass.

Hoffman, Dr. A. H. Indian relics from Angel Island, Cala., (through Surgeon-General's office.)

Hoffman, Dr. W. J. Tortoise from Colorado Desert.

Holmes, G. G. Skull and horns of African Antelope "Koodoo."

Holst, Dr. Chr., University of Christiania, Norway. Collection of minerals from Norway.

Hoover, Jno. T. Nest of small Fly-Catcher from Dansville, N. Y.

Hough, R. B. Nests and eggs of birds from Northern New York.

Hovey, Geo. Specimen of *Gordius* in alcohol.

Howell, R. Indian relics and fossils from Tioga Co., N. Y.

Hurlburt, Geo. H. One box of birds from New Granada.

Imp. Mus. Vienna. See *Pelzeln, A. von.*

Jewett, Col. E. Stone disk from mound at Cedar Key, Fla.

Jones, Dr. Jos. Casts of ancient stone implements from Louisiana.

Jordan, H. C. Alcoholic collections from Brazil and Paraguay.

Junghuuns, Dr. Two human skulls from Japan.

Kalteyer, Geo. H. Fossil tooth (*Ptychodus*) from Texas.

Keenan, T. J. R. Ethnological and other specimens from Mississippi and Louisiana.

Kellogg, *B. B.* Indian stone implements from New Fairfield, Ct.

Kercheval, *A.* Minerals and fossils from West Virginia.

Kerr, *Jno. W.* Eight specimens of Lake White-fish from Lakes Erie and Ontario.

Kiel, *Peter.* One box White-fish from Wolf Island, Ontario.

Knudsen, *Valdemar.* Ethnological and zoological collections from the Sandwich Islands.

Kron, *F. J.* Indian antiquities from North Carolina.

Lee, *Col. J. G. C.* Specimens of Indian pottery and other relics from Arizona.

Lehane, *Jas.*, *Hospital Steward U. S. A.* Specimen of Mountain Rat, (*Neotoma*,) and skin of Horned Owl from Camp Douglas, Utah.

Leidy, *Dr. Jos.* One box ethnological specimens from Wyoming Terr.

Luce, *Capt. S. B.* Specimens of ancient Roman mosaic pavement from Italy.

Ludington, *C.* Fresh fish, shells, &c., from lower Potomac.

Macfie, *R.* One box White-fish from Alburgh Springs, Vt.

Mackenzie, *Jas.* Specimens of corals and shells imbedded in asphalt, from Cuba.

Mackin, *Dr. C.* One jar alcoholic collections from Beaufort, N. C.

Marquardt, *H.* Specimens of Guaco, and Nopal, from Mexico.

Maynard, *C. J.* One box birds, (lent for examination.)

McCallum, *D.* Specimen of Glow-worm.

Mc Williams, *Dr.* Specimen of rose-breasted Grosbeak from Washington, D. C.

Meigs, *Gen. M. C.* One jar alcoholic collections from Arizona, shells, &c., from Lower California.

Merritt, *Jno. F.* Arrow-heads from Northern New York.

Metcalf, W. Birds, &c., from Michigan.

Miller, *J. De Witt.* Indian stone implements from New York.

Miller, *S. A.* Collections of fossils from Ohio.

Milner, *James W.* Collections of fishes, reptiles, &c., dry and in alcohol. from the great lakes.

Möbius, *Dr. Karl*, *University of Kiel*, *Prussia.* Fishes from the Baltic Sea.

Moore, *A. B.* Birds' nests and eggs from Florida.

Moore, *Carleton R.* Indian stone relics from the Eastern Shore of Maryland.

Mori, *Hon. Arinori.* Set of Japanese gold and silver coins, and ethnological specimens from Japan.

Morris, *Jordan*, through *Z. B. Sturgis.* Fragment of fossil Coral (*Favosites*) from Salem, Ind.

Mullet, *A. B.* Two boxes of minerals.

Munson, *Chas.* Specimens of gray copper-ore.

Mus. Comp. Zoology, *Cambridge*, *Mass.* Casts of fossils; two boxes general collections.

Nelson, W. J. Specimen of rock from Virginia.
Nichols, Dr. C. H. Specimens of Jaguar and Monkey from S. America, (died in captivity at Government Hospital for the Insane.)
Nugent, F. F. Birds' nests and eggs from Utah.
Oler, H. D. Indian flint implements from Illinois.
Palmer, Jos. Casts of skulls and alcoholic specimens.
Papineau, E. A. Insects from Kansas.
Peabody Mus. See *Wyman, Dr. Jeffries.*
Pelzeln, Dr. A. von, Imperial Mus. Vienna. One large box skeletons.
Poey, Prof. F. Two casks and one box Cuban fishes, labeled.
Powell, Maj. J. W. General collections from Utah and Arizona.
Powell, Capt. S. One box fishes from Rhode Island.
Prentiss, Dr. D. W. Birds collected in the vicinity of Washington.
Propper, Geo. H. Fossils and ethnological specimens from Dakota Ter.
Putnam, Geo. D. One box insects from Iowa.
Read, Rev. D. One box fresh-water shells from Minnesota.
Reinsch, Dr. Paul. Herbarium of mosses (2 vols.) from Central Europe.
Ricksecker, E. One box of eggs from Nazareth, Pa.
Ring, Lt. F. M. General collections from Alaska.
Robinson, Miss Agnes C. Nest of *Vireo* from vicinity of Washington.
Roessler, A. R. Specimen of copper-glance from Archie Co., Tex.
Rouckendorff, W. Cluster of barnacles.
Royal College of Surgeons, London, Prof. W. H. Flower. Casts of brains and osteological specimens.
Rutter, H. Fresh fish (*Coregoni*) from Fredericton, N. B.
Salt Lake Museum. One box minerals, fossils, &c.
Sarg, Francis. Collections of insects and shells from Guatemala.
Sars, G. O. Embryonic Cod fish from Norway.
Sartorius, Florentin. Four specimens of the wax-producing insect (*Lystra cerifera*) from Mirador, Mex.
Sayre, W. Marine invertebrata from South Carolina.
Scammon, Capt. C. M. Specimens of bones of Cetaceans, &c., from N. W. Coast.
Sceva, Geo. Five boxes of fossils from Pt. Conception, Cal.
Schacht, Bros., Sandusky, O. One box fish-products.
Schoolcraft, Mrs. H. R. Indian flint knife.
Schrock, J. Ethnological specimens from Ohio.
Sherman, Isaac C. Stuffed specimen of Bill-fish, (*Histiophorus gladius.*)
Sinclair, Thos. Specimen of young Sucking-fish from George's Bank.
Spencer, J. W. Fossils from Sullivan Co., Ind.
Stanley, H. O., through *H. T. Richardson.* Six jars Blue Trout from Rangely Lake, Me.
Stearns, R. E. C. One box birds' nests and general collections from California.
Stimpson, Dr. W. Two cases general collections from Florida.
Stone, Livingston. Salmon-eggs from Sacramento River, Cal.

Street, W. Eggs of Hawks from Easthampton, Mass.

Sumichrast, *Dr. F.* General collections from Tehuantepec, Mex.

Surgeon-General U. S. Army. See *Hoffman*, *Dr. A. H.*

Swan, *J. G.*, through *Geo. Gibbs.* Indian implements from Washington Territory.

Thomas, *Gen. H. G.* One box bones of mound-builders from Dakota.

Thompson, *D.* Indian stone relics from Ohio.

Thompson, *J. H.* One jar fishes from New Bedford, Mass.

University of Chili, *Santiago*, *Chili.* See *Domeyko.*

University of Christiania. See *Holst*, *Dr. Chr.*

University of Kiel. See *Möbius*, *Dr. K.*

Unknown. Fossils from Onondaga Co., N. Y. Box of living plants from Washington Ter. Fresh skin of African Gull. One Moth from Erie, Pa. One box specimens from Pa. One box alcoholic specimens and insects. One box fossil bones from North Carolina. One living serpent (*Abastor erythrogrammus*) from Georgia. Ores from Amador Co., Cal. Bones of Mastodon from Mississippi. Silver-ores from Montana. One earthen pipe.

Voorhees, *P. W.* Specimen of bog-iron ore from New Jersey.

Waldo, *Rev. Milton.* One box minerals and fossils from South Carolina.

Walker, *Dr. R. L.* Indian stone hammers and arrow-heads from Pennsylvania.

Wallace, *Jno.* Skeletons of Flamingo and Swan.

Ward, *Prof. H. A.* Skeleton of Buffalo.

Wasson, *Jno.*, *Surveyor-General Arizona.* Specimens of silver-ores from various mines in Arizona.

Watson, *S.* Sets of plants made up for distribution.

Watters, *Dr. W.* Fragment of skin of a *Plagiostome* from Searsport, Me.

Webber, *Mrs.* Specimens of shells in alcohol from Florida.

Westcott, *O. S.* Specimen of Bald Eagle from Illinois.

Wheeler, *Lt. G. M.* General collections from Utah and Arizona.

Wheeler, *W. F.*, *U. S. Marshal.* Skin of Rocky Mountain Goat from Montana Territory.

Whitman, *G. P.* Beak of a Cuttle-fish from Rockport, Me.

Williams, *H. C.* Stone arrows and ax from Fairfax Co., Va.

Wilson, *Dr. J. N.* Copper quiver from near Newark, O.

Wood, *Dr. W. M.* One box general collections.

Woodworth, *O. H.* Specimens of Horned Toad and insects from New Mexico.

Wright, *Chas. D.* Brick from the wall of Pekin, China, (on deposit.)

Wyman, *Dr. Jeffries*, *Peabody Mus.*, *Cambridge*, *Mass.* Three boxes of European prehistoric relics.

Yarrow, *Dr. H. C.* General collections from Ft. Macon, N. C.

Yates, *Dr. L. G.* Minerals and stone relics from California.

Yonge, *Wm. Penn.* Specimen of Shad from Alabama River.

Zaremba, *Dr. C. W.* Fruit and leaves of Chilian Boldo-tree, (*Prunus fragrans.*)

TABLE SHOWING THE STATISTICS OF THE SMITHSONIAN EXCHANGES IN 1872.

Agent and country.	No. of addresses.	No. of packages.	No. of boxes.	Bulk of boxes in cubic feet.	Weight of boxes in pounds.
Royal Swedish Academy of Sciences, Stockholm:					
Sweden	27	73	4	......	....
Royal University of Norway, Christiania:					
Norway	22	58	3	......	....
Royal Danish Society of Sciences, Copenhagen:					
Denmark	25	57	......	......	....
Iceland	2	2	3	......	....
Total	27	59	3	......	....
Watkins & Co., St. Petersburg:					
Russia	89	189	6	.....	....
Frederic Müller, Amsterdam:					
Holland	56	125	4	......	....
Belgium	95	140	4	......	....
Total	151	265	8	......	....
Dr. Felix Flügel, Leipsic:					
Germany	435	626	40	......	....
Switzerland	56	148	4	......	....
Greece	3	3	1	......	....
Total	494	777	45	......	....
Gustave Bossange, Paris:					
France	187	349	8	......	....
R. Istituto Lomb. di Scienze e Lettere, Milan:					
Italy	131	232	5	......	....
Royal Academy of Sciences, Lisbon:					
Portugal	19	19	1	......	....
Royal Academy of Sciences of Madrid:					
Spain	8	8	1	......	....
William Wesley, London:					
Great Britain and Ireland	299	432	27	......	....
Asia	20	22	43	......	....
Cape Town and Mauritius, Africa	4	4	3	......	....
Total	323	458	73	......	....
University of Melbourne:					
Australia	19	20	1	......	....
Parliamentary Library, Wellington:					
New Zealand	5	5	1	......	....
Rest of the world	42	49	20	......	....
Grand total	1,544	2,561	179	954	26,850

METEOROLOGICAL OBSERVERS OF SMITHSONIAN INSTITUTION.

Instruments used: B, barometer; T, thermometer; P, psychrometer; R, rain-gauge.

Name.	Town.	County.	Instruments.	When commenced.
ALABAMA.				
Alison, H. L., M. D	Carlowville	Dallas	TR	1856
Anthony, Dr. E. L	Huntsville	Madison	TR	1871
Hudson, Dr. H. S	Selma	Dallas	BTPR	1872
Hurley, D. P	Troy	Pike	TR	1872
Peters, Thomas M	Moulton	Lawrence	BTR	1866
Tutwiler, Henry	Havana	Hale	TR	1853
Wilson, W. W	Bluff Springs	Clay	R	1872
ARKANSAS.				
Bishop, Harmon	Mineral Springs	Hempstead	TR	1870
Borden, J. E	Washington	do	TR	1872
Greene, E	Clarksville	Johnson	TPR	1871
Jacks, T. M., jr	Helena	Phillips	TR	1872
Martin, Jos. P	Pocahontas	Randolph	TR	1871
McLendon, I. G. P	Mineral Springs	Arkansas	TR	1872
McClung, Charles L	Fayetteville	Washington	TR	1870
Russell, O. F	Helena	Phillips	TR	1865
Wellborn, William T	Forest City	Saint Francis	TR	1872
Whittington, Granville	Mount Ida	Montgomery	TR	1872
CALIFORNIA.				
Abbott, Dr. E. K	Salinas City	Monterey	T	1872
Ames, M. E. Pulsifer	Indian Valley	Plumas	TR	1870
Asher, J. M	National City	San Diego	T	1872
Barnes, Dr. G. W	San Diego	do	BTPR	1871
Canfield, Dr. C. A	Monterey	Monterey	BTPR	1864
Cheney, Dr. W. Fitch	Chico	Butte	TR	1869
Compton, Dr. A. J	Watsonville	Santa Cruz	TR	1869
Thornton, Dr	Mendocino	Mendocino	TR	1869
United States Naval Hospital	Mare Island		BTR	1868
COLORADO.				
Byers, William N	Denver	Arapahoe	TR	1869
Croft, Clayton I	Fountain	El Paso	TR	1871
Lakes, Arthur	Golden City	Jefferson	TR	1872
Nettleton, E. S. and Copley E	Colorado Springs	El Paso	TR	1871
CONNECTICUT.				
Alcott, Rev. William P	Round Hill	Fairfield	BTR	1870
Andrews, Luman	Southington	Hartford	TR	1870
Barnes, Aug	do	do	BTR	1872
Johnston, Prof. John	Middletown	Middlesex	BTPR	1854
Rockwell, Charlotte	Colebrook	Litchfield	TR	1860
Yeomans, William G	Columbia	Tolland	TR	1856
DAKOTA.				
Ambrose, Henry	Fargo	Pembina	BT	1872
Baylis, A. R., and Black, D. S	Second Crossing	Cheyenne	BT	1872
Greene, H. C	Bon Homme	Bon Homme	None.	1872
DELAWARE.				
Bateman, J. H	Dover	Kent	TR	1870
Gilman, R. H	Milford	do	TR	1871
FLORIDA.				
Baldwin, Dr. A. S	Jacksonville	Duval	BTPR	1853
Barker, Edward	Springfield	Jackson	TR	1866

Name.	Town.	County.	Instruments.	When commenced.
FLORIDA—Continued.				
Beecher, Rev. Charles	Newport	Wakulla	TR	1870
Betts, Truman S	Tallahassee	Leon	R	1872
Chamberlin, S. N	Daytona	Volusia	TR	1870
Lowd, Edmond K	New Smyrna	do	TR	1871
Powell, Charles F	Bicalata	Saint John	PT	1871
Robinson, General George D	Pilatka	Putnam	TR	1869
Rollins, John F	Fort George	Duval	T	1872
Sturtevant, E. T	Biscayne	Dade	TR	1872
Thralls, George R	Welborn	Suwanee	TR	1871
White, W. F	Tampa	Hillsborough	TR	1871
GEORGIA.				
Barker, Ebenezer	Saint Mary's	Camden	TR	1870
Colvard, A	Cabaniss	Monroe	TR	1872
Cutter, John L	Quitman	Brooks	TR	1870
Deckner, F., & Son	Atlanta	Fulton	TR	1865
Grant, Dr. W. T	Athens	Clarke	TR	1872
Hillyer, H. L	Saint Mary's	Camden	TR	1869
Hollifield, Hor. N	Sandersville	Washington	TR	1872
McClutchen, A. R	La Fayette	Walker	TR	1871
Sanford, Professor Shelton P	Penfield	Greene	TR	1869
Smith, Dr. F. M	Traders' Hill	Charlton	TR	1872
Stephenson, Dr. M. F	Gainesville	Hall	T	1872
ILLINOIS.				
Aldrich, Verry	Tiskilwa	Bureau	T	1859
Blanchard, O. A	Elmira	Stark	TR	1862
Bowman, Dr. M. B	Andalusia	Rock Island	BTR	1866
Brendel, Fred	Peoria	Peoria	BTPR	1855
Brookes, Samuel	Chicago	Cook	T	1859
Chase, Dr. D. H	Louisville	Clay	TR	1869
Cochrane, Joseph	Havana	Mason	TR	1870
Dudley, Timothy	Warrensburgh	Macon	TR	1867
Duncan, Rev. Alex	Mount Sterling	Brown	TR	1866
Grant, John and Maggie	Manchester	Scott	BTPR	1866
Hamilton, Mrs. M	Jerseyville	Jersey	TR	1872
Hearne, Frank I	Quincy	Adams	TR	1870
Horine, sr., W. H	Waterloo	Monroe	TR	1872
James, J. W	Marengo	McHenry	TR	1869
Langguth, John G	Chicago	Cook	BTPR	1867
Livingston, Professor W	Galesburgh	Knox	BTPR	1861
Marcy, Professor Oliver	Evanston	Cook	BTR	1869
Mead, S. B	Augusta	Hancock	TR	1849
Moss, G. B	Belvidere	Boone	TR	1868
Murray, Peter	Manchester	Scott	TR	1871
Osborn, Ethan	Hennepin	Putnam	TR	1870
Patterson, H. N	Oquawka	Henderson	TR	1870
Phelps, E. S. and Miss L. E	Wyanet	Bureau	TR	1864
Puffer, A. W	Mattoon	Coles	TR	1871
Spaulding, Dr. A. and Mrs	Aurora	Kane	BTPR	1865
Spencer, William C	Dubois	Washington	TR	1865
Whitaker, B	Warsaw	Hancock	TR	1855
INDIANA.				
Alden, Thomas E	Rising Sun	Ohio	TR	1871
Applegate, J. A., and daughter	Mount Carmel	Franklin	TR	1869
Boerner, Charles G	Vevay	Switzerland	BTPR	1864
Chappellsmith John	New Harmony	Posey	BTPR	1852
Clark, W. S	Beech Grove	Rush	TR	1871
Crosier, Adam	Laconia	Harrison	BTR	1869
Dawson, William	Spiceland	Henry	BTR	1863
Deem, D	Knightstown	Rush	BTPR	1868
Evans, Aaron	Cannelton	Perry	BTR	1872
Halleck, E. L	North Liberty	Saint Joseph	TR	1872
Holmes, D. D., Rev. Thomas	Merom	Sullivan	TR	1866
Howard, J. K	Livonia	Washington	TR	1871
Irwin, Albert C	Sweetser	Grant	TR	1868
Robertson, R. S	Fort Wayne	Allen	TR	1870
State University	Bloomington	Monroe	BTPR	1868
Sutton, George	Aurora	Dearborn	BTPR	1859
Williams, Dr. B. C	Steam Corner	Fountain	TR	1869
IOWA.				
Ashley, M. V	Afton	Union	TR	1871
Babcock, E	Boonsborough	Boone	TR	1867

Name.	Town.	County.	Instruments.	When commenced.
IOWA—Continued.				
Bryant, A. F	Fontanelle	Adair	TR	1866
Cornell College	Mount Vernon	Linn	TR	1860
Dickinson, James P	Guttenberg	Clayton	TR	1866
Harris, E. A	Red Oak Junction	Montgomery	TR	1872
Horr, Dr. Asa	Dubuque	Dubuque	BTPR	1851
Jones, J. E	Monticello	Jones	TR	1866
Kridelbaugh & Peterson	Clarinda	Page	TR	1872
Marshall, Gregory	Cresco	Howard	BTR	1871
McBride, T. H	Hopkinton	Delaware	TR	1872
McClintock, Frank	West Union	Fayette	BTR	1869
McCready, Dan'l and Miss Lucy	Fort Madison	Lee	TR	1852
Miller, Edwin and Mrs. R	Grant City	Sac	TR	1869
Nelson, Daniel B	Sac City	do	TR	1870
Ross, F. A	Durand	Cedar	TR	1871
Russell, A. M. and M. M	Atalissa	Muscatine	TR	1871
Sheldon, D. S	Davenport	Scott	BTPR	1867
State University	Iowa City	Johnson	BTPR	1861
Stern, Jacob F	Logan	Harrison	TR	1866
Talbot, Benjamin	Council Bluffs	Pottawattamie	TR	1871
Townsend, Nathan	Iowa Falls	Hardin	TR	1863
Wadey, F	Rockford	Floyd	TR	1868
Walton, J. P	Muscatine	Muscatine	BTR	1863
Warne, Dr. George	Independence	Buchanan	BTR	1867
Warren James H	Algona	Kossuth	TR	1867
Wheaton, Mrs. D. B	Independence	Buchanan	TR	1866
Witter, D. R	Council Bluffs	Pottawattamie	TR	1867
KANSAS.				
Beckwith, W	Olatha	Johnson	TR	1864
Cotton, Wm. H. and John M	Rural	Jefferson	TR	1870
Eagle, R. F	Buffalo Creek	Woodson	TR	1872
Fogle, D	Williamsburgh	Franklin	TR	1871
Henry, W. F	Independence	Montgomery	TR	1872
Horn, Dr. H. B. and Miss	Atchison	Atchison	TR	1865
Hoskinson, Riley M	Burlingame	Osage	TR	1871
Hunt, A. M	Hutchinson	Reno	TR	1872
Hyland, William	Baxter Springs	Cherokee	TR	1867
Lamb, Mrs. W. M	Douglass	Butler	TR	1870
Neiswender, William N	Topeka	Shawnee	TR	1872
Raynolds, J. W. and Carr, Austin	Belleville	Republic	TR	1872
Richardson, A. G	Plum Grove	Butler	TR	1871
Shoemaker, J. G	Le Roy	Coffey	TR	1869
State Agricultural College	Manhattan	Riley	TR	1865
State University	Lawrence	Douglass	BTPR	1868
Stayman, Dr. J	Leavenworth	Leavenworth	TR	1866
Walrad, L. D	Paoli	Miami	TR	1869
Walters, Dr. James	Holton	Jackson	TR	1867
Woodworth, Dr. Abner	Council Grove	Morris	TR	1865
KENTUCKY.				
Beatty, O	Danville	Boyle	BTR	1853
Horr, Edw. W	Blandville	Ballard	TR	1871
Letton, Rev. J. E	Harrodsburgh	Mercer	TR	1872
Martin, Dr. Samuel D	Chilesburgh	Clark	BTR	1865
Ogden, James M	Winchester	do	T	1872
Shriver, Howard	Arcadia	Lincoln	BTPR	1869
Young, Mrs. Lawrence	Springdale	Jefferson	BTPR	1849
LOUISIANA.				
Cleland, Rev. T. H	Delhi	Richland	R	1871
Collins, H. C	Ponchatoula	Tangipahoa	BTR	1870
Foster, Robert W	New Orleans	Orleans	BTR	1867
Leoni, George N	New Iberia	Iberia	TR	1872
Moore, Dr. Jos. L	Shreveport	Caddo	BTPR	1871
Stathem, Isaac	New Orleans	Orleans	BTPR	1872
Turner, Ernest	Point Pleasant	Tensas	BTPR	1872
MAINE.				
Clifford, J. R. and A. J	Montville	Waldo	TR	1871
Colson, J. A	Bucksport	Hancock	BTPR	1872
Fernald, M. C	Orono	Penobscot	BTPR	1870
Gardiner, R. H	Gardiner	Kennebeck	BTPR	1860
Guptill, G. W	Cornish	York	TR	1855
Haskell, W	Bucksport	Hancock	BTPR	1871

Name.	Town.	County.	Instruments.	When commenced.
MAINE—Continued.				
Moore, A. P	Lisbon	Androscoggin	TR	1850
Moulton, John P	Standish	Cumberland	TR	1865
Ohler, W. H	Portland	do	TR	1872
Parker, J. D	Mount Desert	Washington	TR	1849
Pinkham, M. S	Millbridge	do	TR	1872
Pitman, Edwin	Sebec	Piscataquis	TR	1863
Reynolds, Dr. H	East Wilton	Franklin	TR	1871
Smith, H. D	Norway	Oxford	TR	1868
Tripp, Rev. L. S	Surry	Hancock	TR	1870
West, Silas	Cornish	York	BTR	1857
Wilbur, B. F	West Waterville	Kennebec	TR	1863
MARYLAND.				
Curtiss, G. G	Fallston	Harford	TR	1870
Devilbiss, F. J	Sam's Creek	Carroll	TR	1871
Ellicott, James F	Saint Inigoes	Saint Mary's	TR	1871
Goodman, William R	Annapolis	Anne Arundel	BTPR	1856
Hanshew, John K	Frederick	Frederick	BTR	1869
Jourdan, Professor C. H	Emmittsburgh	do	BTPR	1867
Kinsell, E. G	Green Spring Furnace	Washington	TR	1872
McCormick, James O	Woodlawn	Cecil	BTR	1865
Naval Hospital	Annapolis	Anne Arundel	BTR	1871
Shepperd, H. M	Ellicott City	Howard	BTR	1871
Shriver, E. T	Cumberland	Alleghany	TR	1871
Valente, A. X	Woodstock College	Baltimore	TR	1870
Vannort, Dr. E. A	Mount Airy	Kent	TR	1872
MASSACHUSETTS.				
Bacon, William	Richmond	Berkshire	TR	1849
Caldwell, John H	Newbury	Essex	TR	1865
Cunningham, George A	Lunenburgh	Worcester	BTR	1866
Dewhurst, Rev. E	Hinsdale	Berkshire	BTR	1868
Fallon, John	Lawrence	Essex	BTPR	1857
Frost, Benjamin D	Hoosac Tunnel		BTR	1871
Hart, George S	New Bedford	Bristol	TR	1871
Hopkins, Professor Albert	Williamstown	Berkshire	BTR	1868
Lunatic Hospital	Worcester	Worcester	BTPR	1860
Metcalf, Dr. John George	Mendon	do	BTR	1849
Nason, Rev. Elias	North Billerica	Middlesex	BTR	1860
Nelson, S. A. and H. M	Georgetown	Essex	TR	1865
Newcomb, G. S	Kingston	Plymouth	TR	1866
Perry, Rev. John B. and Mrs. Sophia H	Cambridge	Middlesex	T	1868
Rodman, Samuel	New Bedford	Bristol	BTPR	1853
Slade, Elisha	Somerset	do	TR	1872
Snell, Professor E. S	Amherst	Hampshire	BTPR	1849
Teele, Rev. Albert K	Milton	Norfolk	TR	1867
Tucker, Edward T	New Bedford	Bristol	TR	1871
MICHIGAN.				
Bullard, Ransom	Litchfield	Hillsdale	BTR	1865
Ellis, Dr. Edwin	Ontonagon	Ontonagon	TR	1865
Higgins, F. W	Detroit	Wayne	TR	1870
Holmes, E. S., D. D	Grand Rapids	Kent	TR	1865
Kedzie, Professor R. C	Lansing	Ingham	BTPR	1863
Lathrop, O. C	South Haven	Van Buren	TR	1872
Olivet College	Olivet	Eaton	BTPR	1870
Paxton, John W	Alpena	Alpena	BTR	1865
Smith, Rev. George N	Northport	Leelenaw	TR	1865
Streng, L. H	Grand Rapids	Kent	TR	1857
Whelpley, Florence and Thos	Monroe	Monroe	TR	1862
Wilson, William	Happy Valley	Benzie	TR	1870
Winchell, Professor and Mrs	Ann Arbor	Washtenaw	BTPR	1870
MINNESOTA.				
Cheney, William	Minneapolis	Hennepin	BTPR	1864
Paterson, Rev. A. B	Saint Paul	Ramsey	TR	1862
Pendergrast, Solomon	Bonniwell's Mills	McLeod	TR	1872
Pyle, Dr. D	Audubon	Becker	TR	1869
Roe, A. L	Afton	Washington	BTR	1871
Roos, Charles	New Ulm	Brown	BTR	1864
Wadsworth, H. L	Litchfield	Meeker	TR	1870
Wieland, C	Beaver Bay	Lake	TR	1859
Winters, J. K. P	Beaver	Winona	TR	1871

Name.	Town.	County.	Instruments.	When commenced.
MINNESOTA—Continued.				
Woodbury, C. W. and C. E	Sibley	Sibley	TR	1865
Young, Th. M. and Mary H	Koniska	McLeod	TR	1869
MISSISSIPPI.				
Coleman, Thomas B	Holly Springs	Marshall	TR	1870
Fithie, James S	Wasson	Copiah	BTR	1872
Florer, Dr. Thomas W	Marion	Lauderdale	TR	1868
Jennings, Dr. S. H	Baldwin	Lee	TR	1871
Keenan, Mrs. W. E. A	Brookhaven	Lawrence	TR	1867
Payne, John S	Grenada	Yalabusha	TR	1870
Tarrant, John F	Columbus	Lowndes	BTPR	1869
MISSOURI.				
Bond, P. J	Nevada	Vernon	TR	1871
Bullard, Rev. Henry	Saint Joseph	Buchanan	TR	1869
Carlton, A. V	Wet Glaze	Camden	TR	1872
De Wyl, Nicolas	Jefferson City	Cole	BT	1868
Goodwin, Spencer L	Richland	Pulaski	TR	1872
Harris, Wyatt	Mount Vernon	Lawrence	BTR	1871
Kaucher, William	Oregon	Holt	BTPR	1867
Kribben, Bertram D	Saint Louis	Saint Louis	BTPR	1872
Martin Horace	Corning	Holt	TR	1870
McCord, R. H	Willard	Greene	TR	1870
Ruggles, Homer	Rolla	Phelps	TR	1867
Salisbury, S. W	Kansas City	Jackson	BTR	1870
Smith, John M	Hematite	Jefferson	TR	1868
Saint Louis University	Saint Louis	Saint Louis	BTPR	1865
Weston, Arthur H	Gallatin	Daviess	R	1872
MONTANA.				
Koch, Peter	Bozeman	Gallatin	TR	1872
Minesinger, J. M	Missoula	Missoula	TR	1870
Stuart, Granville	Deer Lodge City	Deer Lodge	BTR	1869
NEBRASKA.				
Caldwell, Mrs. Eveline E	Bellevue	Sarpy	TR	1868
Dunn, William	Emerson	Otoe	TR	1871
Hamilton, Rev. William	Omaha Agency	Burt	TR	1867
Kellogg, Edward	Red Cloud	Webster	TR	1872
Seltz, Charles	De Soto	Washington	TR	1867
Smith, Lewis H	New Castle	Dixon	TR	1870
Truman, George S	Santee Agency	L'Eau qui Court	TR	1871
NEW HAMPSHIRE.				
Brewster, Alfred	Tamworth	Carroll	TR	1867
Brown, Branch	Stratford	Coos	TR	1859
Colby, Alfred	Amoskeag	Hillsborough	TR	1868
Couch, E. D	Salisbury	Merrimack	TR	1870
Hurlin, Rev. William	South Antrim	Hillsborough	R	1866
Kidder, L. D	Whitfield	Coos	TR	1869
Mason, E. S	Gorham	do	BT	1872
Odell, Fletcher	do	do	TR	1856
NEW JERSEY.				
Beans, Thomas J	Morristown	Burlington	TR	1865
Brooks, William	Paterson	Passaic	TR	1866
Chandler, Dr. William J	South Orange	Essex	TR	1870
Cook, E. Rezeau	Trenton	Mercer	BTR	1865
Fleming, John	Mount Airy	Hunterdon	TR	1871
Green, H. A	Atco	Camden	TR	1871
Howard, Thomas T., jr	Jersey City	Hudson	BTPR	1871
Ingram, Dr. John	Vineland	Cumberland	BTPR	1867
Noll, Arthur B	New Germantown	Hunterdon	BTR	1868
Palmer, Mrs. J. R	Rio Grande	Cape May	TR	1868
Perry, H. C	Allowaystown	Salem	TR	1871
Sheppard, R. C., and sister	Greenwich	Cumberland	BTPR	1868
Stockwell, Dr. W. H	Orange	Essex	TR	1872
Whitehead, W. A	Newark	do	BTR	1849
NEW YORK.				
Adriance, Charles E	Hector	Schuyler	None.	1871
Arden, Thomas B	Garrison's	Putnam	TR	1860
Arnold, C. P	Angelica	Allegany	TR	1871

Name.	Town.	County.	Instruments.	When commenced.
NEW YORK—Continued.				
Baker, Gilbert D	Milo	Yates	TR	1869
Barrows, Captain Storrs	South Trenton	Oneida	TR	1863
Bartlett, Erastus B	Palermo	Oswego	TR	1860
Bussing, John W. and D. S	Minaville	Montgomery	TR	1867
Clark, B. Wheaton	Lockport	Niagara	TR	1870
Edwards, Daniel	Little Genesee	Allegany	TR	1866
Godfrey, M. P	Carlton	Orleans	TR	1871
Haas, Henry	Depauville	Jefferson	TR	1865
Hachenberg, Dr. G. P	Rochester	Monroe	BTPR	1869
Hendricks, D. B	Near Kingston	Ulster	TR	1869
Heimstreet, John W	Troy	Rensselaer	BTPR	1849
Howell, Robert	Nichols	Tioga	T	1857
Hungerford's Collegiate Institute.	Adams	Jefferson	BTR	1872
Hunt, J. M	North Argyle	Washington	BTR	1870
Ingalsbe, Grenville M	South Hartford	do	TR	1863
Irish, Rev. William	Lowville	Lewis	BTPR	1871
Ives, William	Buffalo	Erie	BTR	1858
Johnson, Rev. Samuel	Groton	Tompkins	TR	1868
Keese, G. Pomeroy	Cooperstown	Otsego	TR	1869
Lee, Leslie A	Canton	Saint Lawrence	TR	1871
Love, Samuel G	Jamestown	Chantauqua	BTPR	1871
Mack, Eli T	Flatbush	Kings	BTR	1862
Mailler, P	Brooklyn	do	BTPR	1870
Malcolm, William Schuyler	Oswego	Oswego	BTR	1854
Merritt, John C	Farmingdale	Queens	None.	1868
Morris, Miss E	Throg's Neck	Westchester	T	1865
Morris, Prof. O. W	New York	New York	BTPR	1849
Partrick, J. M	North Volney	Oswego	TR	1868
Roe, Sanford W	Middleburgh	Schoharie	TR	1866
Russell, Cyrus H	Gouverneur	Saint Lawrence	BTR	1860
Sawyer, G. F	Fairfield	Herkimer	BTPR	1871
Smith, E. A., and daughters	Moriches	Suffolk	TR	1864
Soule, Prof. William	Cazenovia	Madison	BT	1865
Spooner, Dr. Stillman	Oneida	do	TR	1864
Trowbridge, David	Waterburgh	Tompkins	TR	1868
United States Naval Hospital	New York	New York	BTR	1868
Water Works	Brooklyn	Kings	BTPR	1872
Willis, O. R., and daughters	White Plains	Westchester	T	1862
Wooster, Charles A	North Hammond	Saint Lawrence	BTR	1866
Yale, Walter D	Houseville	Lewis	TR	1849
Young, J. M	West Day	Saratoga	TR	1871
NORTH CAROLINA.				
Adams, Prof. E. W	Goldsborough	Wayne	TR	1860
Allison, Thomas H	Statesville	Iredell	TR	1866
Aston, Edw. J	Asheville	Buncombe	TR	1867
Austin, Robert H	Tarborough	Edgecombe	TR	1871
Beal, William	Murphy	Cherokee	TR	1872
Beall, Dr. R. L	Lenoir	Caldwell	TR	1871
Clark, T. A	Weldon	Halifax	TR	1872
Davies, Mrs. D. D	Webster	Jackson	TR	1872
Gilmer, Robert S	Mount Airy	Surry	TR	1872
Hardy, Dr. J. F. E	Asheville	Buncombe	BTR	1868
Hicks, Dr. William R	Oxford	Granville	TR	1867
Hines, Richard N	Edenton	Chowan	TR	1872
Howard, S. A	Greensborough	Guilford	TR	1871
Kitchen, A. E	New Garden	do	BT	1872
Kron, F. J	Albemarle	Stanly	TR	1849
Lawrence, G. W	Fayetteville	Cumberland	TR	1871
Morelle, Rev. Daniel	Wilmington	New Hanover	BT	1872
Murdoch, W. H	Anandale	Wake	TR	1871
Pemberton, S. J	Albemarle	Stanly	T	1872
Rumley, James	Beaufort	Carteret	TR	1872
Siler, Albert	Franklin	Macon	TR	1872
OHIO.				
Baldwin University	Berea	Cuyahoga	BTR	1871
Bareis, August	Groveport	Franklin	TR	1872
Barringer, W	Bellefontaine	Logan	TR	1870
Bingman, T. J	Pennsville	Morgan	TR	1870
Bowman, Peter	Savannah	Ashland	TR	1872
Burras, O	North Fairfield	Huron	TR	1867
Clarke, John	Bowling Green	Wood	TR	1866
Crane, George W	Bethel	Clermont	TR	1859
Ferris, E. J	Painesville	Lake	BTPR	1867

Name.	Town.	County.	Instruments.	When commenced.
OHIO—Continued.				
Hammitt, John W	College Hill	Hamilton	TR	1859
Harper, George W	Cincinnati	do	BTPR	1855
Herrick, L	Oberlin	Loraine	TR	1870
Hyde, Mr. and Mrs	Cleveland	Cuyahoga	BTR	1862
Marsh, Mrs. M. M	Carson	Huron	BTPR	1871
Matthews, Joseph McD	Hillsborough	Highland	BTPR	1851
McFarland, Prof. R. W	Oxford	Butler	BTR	1870
Morton, Dr. George R	North Bass Island	Ottawa	TR	1869
Mount Auburn Young Ladies' Institute.	Mount Auburn	Hamilton	BTPR	1868
Müller, Dr. R	Carthagena	Mercer	BTPR	1870
Neill, Thomas	Sandusky	Erie	BTPR	1859
Otterbein University	Westerville	Franklin	BTPR	1858
Ousley, Dr. J. B	Jacksonborough	Butler	TR	1868
Phillips, R. C	Cincinnati	Hamilton	BTR	1859
Pollock, Rev. J. E	Salem	Columbiana	TR	1870
Rodgers, Alexander P	Gallipolis	Gallia	TR	1857
Shaw, W. S	Savannah	Ashland	BTR	1871
Shields, J. H	Cincinnati	Hamilton	TR	1871
Shreve, Martha B	Martin's Ferry	Belmont	T	1869
Smith, Dr. Charles H	Kenton	Harding	TR	1862
Smith, Charles J	Hudson	Summit	BTR	1871
Stubbs, Jesse	West Elkton	Preble	BTR	1872
Thompson, Rev. David	Birmingham	Guernsey	TR	1862
True, Dr. H. A	Marion	Marion	TR	1865
Urbana University	Urbana	Champaign	BTR	1855
Western Reserve College	Hudson	Summit	BTR	1872
Wilkinson, John R	Williamsport	Pickaway	TR	1867
OREGON.				
Coe, Charles C	Hood River	Wasco	TR	1872
Oxer, Henry A	Portland	Multnomah	BTPR	1871
Pearce, Thomas	Eola	Polk	TR	1870
Wilson, Louis	Astoria	Clatsop	BTPR	1870
PENNSYLVANIA.				
Albree, George	Pittsburgh	Allegheny	TR	1870
Bell, Joseph	Franklin	Venango	TR	1872
Beatley, E. T	Tioga	Tioga	TR	1863
Black, Samuel A	Harrisburgh	Dauphin	BTPR	1869
Burkhalter, John	Meadville	Crawford	T	1872
Cooke, Dr. William H	Carlisle	Cumberland	BTPR	1868
Corson, Samuel M	Plymouth Meeting	Montgomery	BTR	1868
Cummings, I	Tarentum	Allegheny	T	1871
Curtis, A. W	Catawissa	Columbia	TR	1870
Darlington, Fenelon	Parkerville	Chester	TR	1859
Day, Theodore	Dyberry	Wayne	TR	1865
Feicht, Dr. B	Allegheny City	Allegheny	TR	1871
Fenton, Elisha	Grampian Hills	Clearfield	BTR	1864
Grathwohl, John	Nyces	Pike	TR	1865
Haines, N. S	Ringtown	Schuylkill	TR	1872
Hamilton, A. J	Exper. Farm	Indiana	TR	1872
Hance, Ebenezer	Fallsington	Bucks	BTR	1865
Haworth, John	Hazleton	Luzerne	TR	1870
Hoffer, J. R	Mount Joy	Lancaster	BTR	1857
Hubbs, Dr. J. Allen	Brownsville	Fayette	TR	1869
James, Professor C. S	Lewisburgh	Union	BTPR	1855
Jefferis, W. A	West Chester	Chester	TR	1872
Kirkpatrick, James A	Philadelphia	Philadelphia	BTPR	1862
Kohler, Edward	Egypt	Lehigh	TR	1859
Lefever, Jacob	Mount Rock	Cumberland	TR	1871
Madlem, W. F	Ephratah	Lancaster	TR	1871
Marsden, Dr. J. H	York Sulphur Springs	Adams	TR	1871
Martin, Dr. George	West Chester	Chester	BTPR	1868
McConnell, E. M	New Castle	Lawrence	TR	1866
Meehan, Thomas	Germantown	Philadelphia	TR	1859
Packard, D. P	Greenville	Mercer	TR	1871
Raser, John Heyl	Reading	Berks	TR	1857
Sisson, Rodman	Factoryville	Wyoming	TR	1864
Smith, Rev. William, D. D	Cannonsburgh	Washington	BTR	1868
Spencer, Miss Anna	Horsham	Montgomery	BTR	1864
Spera, W. H	Ephratah	Lancaster	BTR	1865
Stocker, Jas. D. and Jerome T	Salem	Wayne	TR	1869
Stump, J. M. L	Greensburgh	Westmoreland	TR	1871
Taylor, John	Connellsville	Fayette	TR	1849
Taylor, Rev. R. T	Beaver	Beaver	T	1867

Name.	Town.	County.	Instruments.	When commenced.
PENNSYLVANIA—Continued.				
Tolman, Rev. M. A	Franklin	Venango	TR	1867
United States Naval Hospital	Philadelphia	Philadelphia	BTR	1857
Walker, S. C	Fountain Dale	Adams	PTR	1868
Weaver, W. D	Greensburgh	Westmoreland	BTPR	1872
RHODE ISLAND.				
Barber, W. A	Newport	Newport	TR	1870
SOUTH CAROLINA.				
Busby, D. Benjamin	Pomaria	Newberry	TR	1872
Cornish, Rev. John H	Aiken	Barnwell	BTR	1857
Gibbon, Lardner	Hacienda Saluda	Greenville	TR	1871
Pearsall, E. D	Grahamsville	Beaufort	TR	1872
Petty, Charles	Gowdysville	Union	TR	1868
TENNESSEE.				
Amsden, E. W	Jackson	Madison	TR	1872
Bancroft, Rev. C. F. P	Lookout Mountain	Hamilton	BTR	1867
Bluhm, P. C	Smithville	DeKalb	TR	1872
Calhoun, P. B	Austin	Wilson	TR	1868
Doak, W. S. and S. S	Greenville	Greene	TR	1868
Franklin, Dr. W. E	Lagrange	Fayette	TR	1870
Grigsby, William T	Trenton	Gibson	TR	1869
Jennings, Dr. S. K	Bethel Springs	McNairy	TR	1872
Kennedy, Dr. Thomas J	Castalian Springs	Sumner	TR	1872
Lewis, Miss Blanche	McMinnville	Warren	TR	1872
Lewis, Charles H	Elizabethtown	Carter	TR	1868
Payne, Professor J. K	Knoxville	Knox	BTPR	1869
Stewart, Professor William	Clarksville	Montgomery	BTPR	1851
Waterbury, Rev. C	Rotherwood	Hawkins	TR	1872
Wright, T. P	Clearmont	Warren	TR	1870
TEXAS.				
Anderson, Rev. John	Clarksville	Red River	TR	1870
Connell, Miss Jane	Houston	Harris	T	1867
Davis S. and Mrs. Rush	Greenville	Hunt	TR	1871
Fietsam, James	Bluff	Fayette	TR	1870
Glasco, J. M	Gilmer	Upshur	TR	1859
Martin, Allen	Clarkville	Red River	TR	1871
Melchert, William	Boerne	Kendall	TR	1872
Pettersen, Fred	San Antonio	Bexar	BTPR	1870
Runge, C	New Ulm	Austin	TR	1872
Scott, T. M	Highland	Collin	TR	1872
Simpson, F	Oakland	Colorado	TR	1872
Van Nostrand, J	Austin	Travis	TR	1857
Wade, F. S	McDade	Burleson	TR	1869
White, Dr. A. C	Clinton	De Witt	TPR	1869
Woodruff, L	Lockhart	Caldwell	R	1868
UTAH.				
Bullock, Thomas	Salt Lake City	Salt Lake County	TR	1868
Harrison, E. L. T	do	do	TR	1872
Lewis, James	Harrisburgh	Washington	R	1867
VERMONT.				
Barto, D. C. and M. E	Panton	Addison	TR	1869
Cassino, Edson S	Lunenburgh	Essex	BTPR	1872
Cutting, Dr. H. A	do	do	BTR	1859
Kennedy, James C	South Troy	Orleans	TR	1870
Normal School	Castleton	Rutland	BTPR	1852
Paine, Charles S	East Bethel	Windsor	TR	1866
Phelps, Samuel B	Norwich	do	TR	1871
Wild, Rev. E. P	North Craftsbury	Orleans	TR	1867
Wing, Minerva E	West Charlotte	Chittenden	TR	1868
Woodstock Academy	Woodstock	Windsor	TR	1868
VIRGINIA.				
Bowman, George A	Vienna	Fairfax	TR	1870
Brown, Rev. James A	Wytheville	Wythe	BTR	1868
Chamberlin, Mrs. S. E	Waterford	Loudon	TR	1871
Clarke, Dr. and Miss Belle	Mount Solon	Augusta	TR	1855

Name.	Town.	County.	Instruments.	When commenced.
VIRGINIA—Continued.				
Covell, J. C	Staunton	Augusta	BTPR	1868
Gillingham, Chalkley	Woodlawn	Fairfax	BTR	1870
Born, Captain D. B	Cedar Hill	Albemarle	TR	1871
Martin, William A	Mechanicsville	Fauquier	TR	1869
Merriwether, Charles I	Lynchburgh	Bedford	TR	1868
Moore, C. R	Johnson Town	Northampton	BTR	1868
Payne, D	Markham Station	Fauquier	TR	1871
Shriver, Howard	Wytheville	Wythe	BTPR	1872
Shuman, James M	Hampton	Elizabeth	TR	1869
Tayloe, Edward T	Comorn	King George	TR	1849
Townsend, Emma C	Capeville	Northampton	TR	1871
United States Hospital	Norfolk	Norfolk	BTR	1868
Vincent, G. C	Richmond	Henrico	TR	1872
Williams, Franklin	Near Piedmont	Fauquier	TR	1869
Williams, H. C	Near Vienna	Fairfax	TR	1869
WASHINGTON.				
McCall, Charles	Cathlamet	Waukiakum	TR	1870
Sampson, Alexander M	Port Angelos	Clallam	TR	1869
Whitcomb, Thomas M	Union Ridge	Clark	TR	1871
WEST VIRGINIA.				
Roffe, Charles L	Ashland	Cabell	TR	1865
Stevens, Professor S. G	Morgantown	Monongalia	BTR	1872
WISCONSIN.				
Beloit College	Beloit	Rock	BTR	1871
Benton, Elliott H	Le Roy	Dodge	TR	1872
Breed, J. Everett	Embarrass	Waupaca	TR	1864
Curtis, W. W	Rocky Run	Columbia	TR	1859
DeLyser, John	Hingham	Sheboygan	TR	1868
Dungan, John L	New Lisbon	Juneau	T	1867
Lapham, I. A., LL. D	Milwaukee	Milwaukee	BTPR	1849
Lups, Jacob and Miss Clarina	Manitowoc	Manitowoc	BTR	1857
Maguire, Felix	Mosinee	Marathon	TR	1870
Mead, H. C	Waupaca	Waupaca	T	1863
Pinney, Mrs. C. C	Sturgeon Bay	Door	TR	1870
Shints, Henry J	Edgerton	Rock	TR	1867
State University	Madison	Dane	BTPR	1869
Tate, Andrew	Bayfield	Bayfield	TR	1867
Waite, M. C	Baraboo	Sauk	TR	1864
Whiting, W. H	Geneva	Walworth	TR	1863
WYOMING.				
Lewis, George H	Atlantic	Sweet Water	T	1872

State.	Number of observers.	Number of barometers.	Number of thermometers.	Number of psychrometers.	Number of rain-gauges.	State.	Number of observers.	Number of barometers.	Number of thermometers.	Number of psychrometers.	Number of rain-gauges.
Alabama	7	2	6	1	7	Montana	3	1	3	0	3
Arkansas	10	0	10	1	10	Nebraska	7	0	7	0	7
California	9	3	9	2	7	New Hampshire	8	1	7	0	7
Colorado	4	0	4	0	4	New Jersey	14	6	14	3	14
Connecticut	6	3	6	1	6	New York	44	17	41	8	38
Dakota	3	2	2	0	0	North Carolina	21	3	21	0	18
Delaware	2	0	2	0	2	Ohio	36	17	36	8	35
Florida	12	1	11	2	10	Oregon	4	2	3	0	3
Georgia	11	0	11	0	10	Pennsylvania	44	13	44	6	41
Illinois	27	7	27	5	25	Rhode Island	1	0	1	0	1
Indiana	17	8	17	5	17	South Carolina	5	1	5	0	5
Iowa	28	6	28	3	28	Tennessee	15	3	15	2	15
Kansas	20	1	20	1	20	Texas	15	1	14	2	14
Kentucky	7	4	7	2	6	Utah	3	0	2	0	3
Louisiana	7	5	6	3	7	Vermont	10	3	10	2	10
Maine	17	5	17	4	17	Virginia	19	6	19	2	19
Maryland	13	6	13	2	13	Washington Ter	3	0	3	0	3
Massachusetts	19	10	19	4	18	West Virginia	2	1	2	0	2
Michigan	13	5	13	3	13	Wisconsin	16	4	16	2	14
Minnesota	11	3	11	1	11	Wyoming	1	0	1	0	0
Mississippi	7	2	7	1	7						
Missouri	15	6	14	3	14	Total	536	148	524	79	504

Besides the observers making monthly reports upon Smithsonian blank forms, the institution receives regular returns from—

The Chief Signal Officer, United States Army, daily records, including weather maps.

From the Central Park observatory, New York, weekly.

From Chas. G. Ewing, San Francisco, newspaper slips from the Alta California, containing meteorological observations, monthly.

Some of the observers furnish, in addition to their reports, more detailed descriptions of various meteorological phenomena.

Müller, *Dr. R.*, Theological Seminary, Carthagena, Ohio, monthly.

Williams, *Rev. R. G.*, Castleton, Vermont, hourly meteorological observations, observations on magnetic variations, &c.

Wing, *Miss M. E.*, West Charlotte, Vermont, manuscript notes on the winds and the weather in general, record of periodical phenomena, &c.

Printed summaries or abstracts from newspapers or agricultural publications are mentioned in the list of additional meteorological material.

BRITISH AMERICA.

NOVA SCOTIA:

Acadia College, Wolfville, King's Province, BTR; D. F. Higgins, the present observer. The college has sent observations since 1854.

NEW BRUNSWICK:

Murdock, *Gilbert*, St. John, BTPR; since 1850.

CANADA:

Stewart, *James*, Province Manitoba, Selkirk County, BTPR; since 1869.

NEWFOUNDLAND:

Delaney, John, Saint John's, BTR, 1871.
Clift, Henry A., Harbor Grace, remarks on aurora, &c., in MS., 1872.
Munn, Archibald, Harbor Grace, TR; 1872.

QUEBEC:

Gilmour, Arthur H. I., Stanbridge, Missisquoi County, TR; since 1868.

ONTARIO:

Wylie, Wm., Mount Forest, Wellington, and Grey Counties, BTPR. Reports of Mount Forest Grammar School, weekly, 1872.

REPORT OF THE EXECUTIVE COMMITTEE.

The Executive Committee of the Board of Regents respectfully submit the following report in relation to the funds of the Institution, the receipts and expenditures for the year 1872, and the estimates for the year 1873:

STATEMENT OF THE FUND AT THE BEGINNING OF THE YEAR 1873.

Amount originally received as the bequest of James Smithson, of England, deposited in the Treasury of the United States, in accordance with the act of Congress of August 10, 1846	$515,169 00
Residuary legacy of Smithson, received in 1865, deposited in the Treasury of the United States, in accordance with the act of Congress of February 8, 1867	26,210 63
Total bequest of Smithson	541,379 63
Amount deposited in the Treasury of the United States as authorized by act of Congress of February 8, 1867, derived from savings of income and increase in value of investments	108,620 37
Total permanent Smithson fund in the Treasury of the United States, bearing interest at 6 per cent., payable semi-annually in gold	650,000 00
In addition to the above there remains of the extra fund from savings, &c., in Virginia bonds, at par value, $88,125.20, now valued at	37,000 00
Cash balance in First National Bank, 1st January, 1873 ..	17,811 36
Total Smithson funds 1st January, 1873	704,811 36

The Virginia stock has risen in value during the past year, and as the prospect is that the legislature of the State will make provision for the regular payment of the interest, the probability is that this stock will continue to rise.

During the past year, the Institution has received from its agents, Messrs. Riggs & Co., on account of back interest on Virginia bonds, after deducting expenses, $3,004.90, in regard to which a detailed account is given in a communication of the Secretary to the Board at its meeting of January 16th.

The balance at the beginning of the year, $17,811.36, as given in the foregoing statement as a part of the Smithson fund, has not been invested because it is required to pay bills as they become due, previous to receiving the semi-annual income at the end of June, 1873, or, in other words, to support the Institution during the accumulation of the first half year's semi-annual interest.

STATEMENT OF RECEIPTS FROM THE SMITHSON FUND FOR 1872.

Interest on $650,000, at 6 per cent. in gold	$39,000 00
Premium on gold June and December, (13⅜ and 11¾)	4,911 55
Interest on Virginia stock, less commissions	3,004 90
Total receipts	46,916 45
Total expenditures from the Smithson income during 1872, as shown by the detailed statement given below	45,420 11
Balance unexpended	1,496 34

The above balance is added to the uninvested savings from previous years, viz, $16,315.02, making the $17,811.36 found in the preceding general statement of the condition of the funds.

EXPENDITURES FROM THE SMITHSON FUND FOR 1872.

Building.		
Reconstruction and repairs	$6,672 35	
Furniture and fixtures	1,625 87	
		$8,298 22
General expenses.		
Meetings of the board	$155 50	
Lighting the building, exclusive of Museum	217 67	
Heating the building, exclusive of Museum	754 00	
Postage, exclusive of Museum	320 73	
Stationery, exclusive of Museum	541 62	
Incidentals, exclusive of Museum	525 62	
Salaries, clerk-hire, and labor	11,153 83	
		13,668 97
Publications and researches.		
Smithsonian Contributions, quarto	$6,394 17	
Miscellaneous Collections, octavo	1,661 99	
Annual reports, octavo	527 50	
Meteorology	2,550 00	
Apparatus	645 00	
Laboratory	169 87	
Lectures	600 00	
		12,548 53

Exchanges.

Literary and scientific exchanges through agencies in London, Paris, Leipsic, Amsterdam, Stockholm, &c...	$5,870 32

Museum.

Salaries, preservation of collections, &c., paid from the Smithsonian income in addition to the sums drawn from the appropriations by Congress	5,034 07
Total expenditure from the Smithson fund in 1872, as given above	45,420 11

During the past year the Institution has advanced money for the payment of freight on specimens, the purchase of apparatus for Government expeditions, &c., the repayments of which, together with the amount received for sales of publications and old material, have been deducted from the several items of the foregoing expenditures, as follows:

From museum, for repayments for freight	$610 03
From exchanges, for repayments for freight	462 81
From apparatus, for instruments for expeditions	1,306 23
From lectures, for advance for scientific course	382 20
From Smithsonian Contributions and Miscellaneous Collections, for copies sold	307 36
From building and incidentals, for sale of old material	44 68
Total repayments and miscellaneous credits in 1872	3,113 31

The estimates for the year 1873 are as follows:

ESTIMATES.

Receipts.

From interest on the permanent fund, in gold, to be received June 30, 1873	$19,500 00
To be received December 31, 1873	19,500 00
Probable premium on gold at 10 per cent	3,900 00
From interest on Virginia stock	1,700 00
Total receipts	44,600 00

Appropriations.

For building	$3,000 00
For general expenses	13,000 00
For publications and researches	20,000 00
For exchanges	7,000 00
For contingencies	1,600 00
	44,600 00

NATIONAL MUSEUM.

Until the year 1870, the support of the National Museum had principally devolved on the Smithsonian Institution, only $4,000 having been annually appropriated by Congress for this purpose. Since that date, however, Congress has indicated the intention of providing for the full support of the Museum, as is evident from the following extracts from the annual appropriation acts:

Smithsonian Institution: For preservation of the collections of the surveying and exploring expeditions of the Government, ten thousand dollars..................... 41st Cong., Sess. II, Chap. 292, Stat. at Large 1869–'71, p. 295. Act (July 15, 1870) making appropriations for sundry civil expenses, &c., for the fiscal year ending June 30, 1871.	$10,000 00
Smithsonian Institution: For preservation of the collections of the surveying and exploring expeditions of the Government, ten thousand dollars..................... 41st Cong., Sess. III, Ch. 114, Stat. at Large 1869–'71, p. 500. Act (March 3, 1871) making appropriations for sundry civil expenses of the Government, &c., for the fiscal year ending June 30, 1872.	10,000 00
Smithsonian Institution: For preservation of the collections of the surveying and exploring expeditions of the Government, fifteen thousand dollars................. 42d Cong., Sess. II, Ch. 415 Stat. at Large 1871–'72, p. 361. Act (June 10, 1872) making appropriations for sundry civil expenses, &c., for the fiscal year ending June 30, 1873.	15,000 00

It should be noted in regard to the above appropriations that the fiscal year of Government is not the same as that of the Institution, the former ending on the 30th of June, and the latter on the 31st of December. From this fact it follows that although the last appropriation of Congress is $15,000 for the care of the Museum, yet the amount available from this appropriation, in 1872, was only $7,500, or the first half of the appropriation for the fiscal year ending 30th June, 1873.

Besides this, however, there was drawn the whole appropriation for the fiscal year ending 30th of June, 1872, viz, $10,000, the first half of which should have been drawn the previous year, and thus have diminished the expenditure from the Smithson income for the Museum in 1871.

The following is therefore a statement of the receipts and expenditures for the care of the National Museum in 1872:

Appropriation by Congress for the first half of the fiscal year ending 30th June, 1872, viz, July to December, 1871.	$5,000 00
Appropriation by Congress for the first half of the fiscal year ending 30th June, 1872, viz, January to June, 1872.......	5,000 00
Total for fiscal year ending 30th June, 1872...........	10,000 00
Appropriation by Congress for the first half of the fiscal year ending 30th June, 1873, viz, July to December, 1872.....	7,500 00
Total from congressional appropriation............	17,500 00
Also from Smithson income for 1872, as shown in the preceding statement..	5,034 07
Making a total for the care of the Museum..........	22,534 07

This large expenditure was necessary for the preservation of a number of perishable specimens, the mounting of the large casts of fossils presented by Professor Henry A. Ward, of Rochester, N. Y., the preparation of numerous skeletons, the transfer of the Mineralogical and Geological Museum of the Government from the General Land-Office to the Smithsonian building, and the preliminary examination of the specimens of which it consisted.

The cost of the reconstruction of the building after the fire of 1865, exclusive of furniture, was $136,000, the whole of which was paid from the funds of the Institution for restoring the main building, and not for fitting up the rooms wanted for the further extension of the Museum. For the latter purpose Congress has made provisions in the following acts:

Smithsonian Institution: Toward the completion of the hall required for the Government collections, ten thousand dollars......	$10,000 00
41st Cong., Sess. II, Ch. 292, Stat. at Large 1869–'71, p. 295. Act (July 15, 1870) making appropriations for sundry civil expenses, &c., for the fiscal year ending June 30, 1871.	
Smithsonian Institution: For the completion of the hall required for the Government collections, ten thousand dollars.....	10,000 00
41st Cong., Sess. III, Chap. 114, Stat. at Large 1869–71, p. 501. Act (May 3, 1871) making appropriations for sundry civil expenses of the Government for the fiscal year ending June 30, 1872.	

Smithsonian Institution: To commence the proper fitting up, in a fire-proof manner, of the vacant apartments in the Smithsonian Institution building, for the proper distribution and exhibition of the Government collections of natural history, geology, and mineralogy, five thousand dollars	$5,000 00
42d Cong., Sess. II, Ch. 172, Stat. at Large 1871–'2, p. 131. Act (May 18, 1872) making appropriations to supply deficiencies in the appropriations for the service of the Government for the fiscal year ending June 30, 1872, and for former years.	
Smithsonian Institution: For the completion of the hall required for the Government collections, ten thousand dollars	10,000 00
42d Cong., Sess. II, Chap. 415, Stat. at Large, p. 361. Act (June 10, 1872) making appropriations for sundry civil expenses of the Government for the fiscal year ending June 30, 1873.	

Of these appropriations, $20,000 were expended in 1871 on account of ceiling, flooring, plastering, and finishing halls for the extension of the Museum; and in 1872, $2,962.50 for cases for the geological hall, leaving available for the first half of 1873, for finishing these cases, and for commencing those for the large hall in the second story of the main building, $12,037.50.

The foregoing expenditures for fitting up rooms for the Museum, $2,962.50, as well as those for the care and preservation of the collections, $17,500, have been accounted for to the Secretary of the Interior, as in previous years.

The Executive Committee have examined thirteen hundred and ninety-five receipted vouchers for payments made during the four quarters of the year 1872, both from the Smithson fund and the appropriations from Congress. In every voucher the approval of the Secretary of the Institution is given, and the certificate of an authorized agent of the Institution is appended, setting forth that the materials and property and services rendered were for the Institution, and to be applied to the purposes stated.

The quarterly accounts-current, bank-book, check-book, and ledger have also been examined and found correct, showing a balance in the First National Bank, 1st of January, 1873, of $17,811.36.

Respectfully submitted.

PETER PARKER,
JOHN MACLEAN,
W. T. SHERMAN,
Executive Committee.

JANUARY 20, 1873.

JOURNAL OF PROCEEDINGS OF THE BOARD OF REGENTS OF THE SMITHSONIAN INSTITUTION.

THURSDAY, *January* 16, 1873.

A meeting of the Board of Regents of the Smithsonian Institution was held this day, at 6 o'clock p. m. Present: The Chancellor Chief Justice Chase, Hon. S. Colfax, Hon. H. Hamlin, Hon. L. Trumbull, Hon. J. W. Stevenson, Hon. J. A. Garfield, Hon. L. P. Poland, General Sherman, Professor Agassiz, Hon. Peter Parker, Rev. Dr. John Maclean, and Professor Henry, the Secretary.

The Chancellor being unable to be present at the beginning of the meeting, Hon. Mr. Hamlin was called to the chair.

The Chancellor arriving at 7 o'clock, assumed his official position as presiding officer of the Board.

The Secretary informed the Board that since its last meeting the death of Hon. Garrett Davis of the United States Senate had occurred, and that the vacancy thus created in the Board of Regents had been filled by the appointment of Hon. J. W. Stevenson, a Senator from the State of Kentucky; whereupon, on motion of General Garfield, the following resolutions were adopted:

Resolved, That the Board of Regents have heard the announcement of the death of their highly esteemed colleague, Hon. Garrett Davis, of Kentucky, with deep and sincere regret.

Resolved, That in the death of Mr. Davis the Smithsonian Institution has lost a warm friend, an efficient supporter, and judicious adviser; and the country a patriotic, virtuous, and influential citizen.

Resolved, That these resolutions be entered upon the journal, and a copy of them be transmitted to the family of the deceased.

The Secretary presented to the Board an exhibit on a large diagram of the condition of the funds on the 1st of January, 1873, and of the receipts and expenditures during 1872.

On motion of Mr. Hamlin, these exhibits were referred to the Executive Committee.

Hon. Peter Parker, in behalf of the Executive Committee, made substantially the following preliminary report:

"The Secretary, who by law is the custodian of the Smithsonian funds, has presented to the Regents an ocular exhibit of the present condition of these funds, and the Executive Committee have, at the present time, to state that they have been laboriously engaged for several days in examining 1,395 vouchers for the expenditures of the Institution for the past year; and comparing these with the bank account, as well as the appropriations from Congress, find the whole in accordance with the statement in the diagram submitted by the Secretary, there being a balance now on hand in the First National Bank of $17,811.36. At the next meeting the committee will present a detailed statement of all the accounts, with estimates of the receipts and appropriations for the year 1873."

The Secretary presented the following statement relative to the *interest* on the *Virginia* stock held by the Institution, as furnished by Riggs & Co.:

1870.	Jan. 16.	2 per cent. interest on $53,500, less $5.35	$1,064 65	
1872.	June 21.	⅔ of $1,761 coupons, $1,174, less ¼, $4.40..........	1,169 60	
	Aug. 2.	⅔ of $1,761 coupons, $1.174, less ¼ and tax, $77.77..	1,096 23	
				$3,330 48
1871.	Dec. 23.	To ¼ per cent. commission on funding, $88,125 20....	$220 31	
1872.	Jan. 12.	To ⅛ per cent. commission on $58,700, conversion of registered to coupon bonds.....................	73 37	
	June 21.	To express charge on $58,700, bonds sent to Richmond for affixing State seal, inadvertently omitted	29 20	
	Aug. 2.	To express on $1,761 coupons to Richmond..........	1 20	
	Aug. 2.	To express on $1,761 coupons to Richmond..........	1 50	
				325 58
1872.	Nov. 9.	Balance paid by Riggs & Co. to the Institution		3,004 90

This communication was referred to the Executive Committee.

The subject of the deposit of the articles of fine art belonging to the Institution in the Corcoran Art Gallery was presented by the Secretary; and, on motion of General Garfield, it was

Resolved, That the Executive Committee and the Secretary report as to the character and organization of the Corcoran Art Gallery, and the plan to be adopted by the Smithsonian Institution in co-operating with that establishment and in depositing articles with it.

Dr. Maclean presented a statement relative to the claim for the portrait of Washington, and stated that a report would be presented on the subject by the Executive Committee at the next meeting.

The Secretary presented the part of his annual report of the operations of the Institution during 1872 relative to original researches, viz: the planet Uranus; the tides; altitudes of over 16,000 different places in the United States; isothermal map; rain tables; winds and underground temperatures.

On motion, the Board adjourned to meet on Monday, January 20, at 7 o'clock p. m.

MONDAY, *January* 20, 1873.

A meeting of the Board was held this day at 7 o'clock p. m.

Present: The Chancellor Chief Justice Chase, Hon. H. Hamlin, Hon. J. W. Stevenson, Hon. L. Trumbull, Hon. J. A. Garfield, Hon. L. P.

Poland, General Sherman, Hon. Peter Parker, Professor L. Agassiz, Rev. Dr. John Maclean, and the Secretary, Professor Henry.

The Chancellor took the chair.

The minutes of the last meeting were read and approved.

Excuses for non-attendance were received from Messrs. Colfax, Cox, and Cooke.

Hon. Peter Parker submitted the report of the Executive Committee, which was read, and, on motion of Mr. Poland, was accepted.

Dr. Maclean, from the Executive Committee, presented a report adverse to the claim for a portrait of Washington painted by C. W. Peale.

On motion of Mr. Hamlin, the report was accepted, ordered to be filed, and a copy to be furnished to the claimant.

The Secretary stated that during the last session of Congress, mainly through the efforts of Mr. Hamlin, the following provision had been adopted in regard to postage facilities:

"All publications sent or received by the Smithsonian Institution, marked on each package "Smithsonian Exchange," shall be allowed to pass FREE IN THE MAIL."

[New Postal Code, 6th Sub-div., 184th Sec., June, 1872.

This does not provide for letters, nor specimens of natural history; and since the transfer of the museum of the Land-Office to the Institution, the postage on minerals sent by the United States surveyors had become a considerable item of expense. The Secretary of the Interior, however, had offered to receive for the Institution all such specimens, if sent by mail to that Department.

Mr. Hamlin stated that a bill had passed the House of Representatives abolishing the franking privilege, and if it passed the Senate the Institution would again have to pay postage.*

The Secretary stated that the New York, Newfoundland, and London Cable Telegraph Company, and the Western Union Telegraph Company had liberally granted the privilege the Institution had requested, to transmit without charge between Europe and America announcements of astronomical discoveries, such as planets, comets, &c.

On motion of Mr. Hamlin, the following resolution was adopted:

Resolved, That the thanks of the Board of Regents of the Smithsonian Institution be tendered to the New York, Newfoundland, and London Telegraph Company, and to the Western Union Telegraph Company, for their grant of the free transmission of telegrams relative to astronomical discoveries.

The Secretary stated that Mr. George Catlin, the Indian traveler and student of ethnology, who had exhibited his sketches of Indian life in the Institution, died in December last, and as it was very desirable that his valuable ethnological collection should be preserved, and, if possible, secured by Congress, it was proper that the Board of Regents should take some action in regard to the matter.

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* This bill has since become a law.

Professor Agassiz commended the collection as of great ethnological value, and expressed the opinion unhesitatingly that it ought to be purchased by the Government.

On motion of General Garfield, it was resolved that the Executive Committee ascertain from the heirs of Mr. Catlin the terms on which his Indian paintings, sketches, specimens, &c., can be procured, and furnish the information, with such recommendation as they think proper, to the Library Committee of Congress.

General Garfield presented the subject of the proposed endowment of agricultural colleges in a bill which had passed the Senate and was now before the House, and expressed the hope that some action could be taken to secure the benefit of the act to the Smithsonian Institution.

Professor Agassiz remarked that there were other institutions in the country that were well worthy to share with this Institution any benefits which might be derived from the distribution of the proceeds of the sales of the public lands; especially the Museum of Comparative Zoology in Cambridge. This museum now contains the largest collection of specimens for the illustration of some departments of zoology of any in the world, and has been supported at an annual expense of from fifty to sixty thousand dollars, principally raised from donations of the friends of the establishment. Professor Agassiz also observed that he thought Professor Henry, in the distribution of specimens abroad, ought in all cases to ask for a return of an equivalent in kind. By not doing so he interfered with the growth of other establishments of a similar character in this country, and especially with the museum at Cambridge.

In reply Professor Henry stated that the policy of the Institution from the beginning had been of a most liberal character; that its motto was "co-operation, not monopoly;" that it had endeavored to co-operate with all institutions in this country and abroad; that the bequest was for the benefit of *men*, not for men of this country alone, but of every country. Whenever specimens have been wanted for scientific research, these specimens have been sent as far as the means of the Institution would allow, and in cases where specimens were required for special investigation in this country, the Institution has endeavored to procure them for the object required. It is true a return in kind has not been asked for because the appropriation from Congress for the support of the museum has not been more than one-fourth of the actual cost, and the Institution has not had the means to pay for transportation of the specimens and the care of those not immediately wanted for research. It has, however, in all cases distinctly announced, in presenting specimens to foreign institutions, that suitable returns would be expected from the duplicates in their collections whenever the Institution might desire to obtain them.* The Institution has in this way a large accumulation of credit abroad, and now that the Government has commenced to make more liberal provision for the support of the National Museum, it may begin to ask for specimens in return, and in doing so may harmoniously co-operate with the Museum of Comparative Zoology by procuring specimens for it, and in receiving from the latter others in return.

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*See Appendix "G" to the Journal of the Board.

At the request of the Board, Professor Agassiz then gave an account* of his late expedition from Boston through the Straits of Magellan to San Francisco, in the steamer Hassler, of the United States Coast Survey, after which the Board adjourned to meet at the call of the Secretary.

WEDNESDAY, *February* 13, 1873.

A meeting of the Board of Regents was held this day, at 7 o'clock p. m. Present: Chief Justice Chase, Chancellor, Hon. H. Hamlin, Hon. L. Trumbull, Hon. J. A. Garfield, Hon. L. P. Poland, Hon. Peter Parker, Hon. H. D. Cooke, and the Secretary, Professor Henry.

The Chancellor took the chair.

The minutes of the last meeting were read and approved.

Dr. Parker presented the following report of the committee relative to the Corcoran Art Gallery:

The committee to whom was referred the subject of inquiry into the character and organization of the Corcoran Art Gallery,† and the plan (if any) to be adopted by the Smithsonian Institution in co-operating with that establishment and in depositing articles with it, and report thereon, have to state: They learn that the Corcoran Art Gallery was incorporated by act of Congress on the 24th of May, 1870, [as appears from Statutes at Large, Forty-first Congress, second Session, chapter 3, page 139,] and is in no way connected with the District or territorial government of Washington.

Your committee have conferred with Mr. W. W. Corcoran, and learn from him his desire in relation to the art gallery bearing his name is to make it one of very high order of art, and, with some exceptions which he specified, he is of the opinion the specimens of the Smithsonian will not come within the scope of his design. The proffer of the aid of the Smithsonian Institution, through its extensive foreign correspondents and agencies, in collecting valuable works of art from abroad, will be highly appreciated by Mr. Corcoran and the Directors of the Corcoran Art Gallery.

PETER PARKER,
W. T. SHERMAN,
Committee.

FEBRUARY 13, 1873.

On motion of Mr. Hamlin, the following resolution was adopted:

Resolved, That the report of the committee be accepted, and, in view of the facts stated, no further action in the premises is required, except so far as relates to co-operation of the Smithsonian Institution in obtaining for the Corcoran Art Gallery contributions from abroad when requested by the directors and at the expense of the corporation.

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*See Appendix "A" to Journal of the Board.

†See Appendix "C" to Journal of the Board.

The Secretary announced the death of Professor James H. Coffin, who had for many years been associated with the Institution in its meteorological work, and had nearly finished a very elaborate paper on the winds of the globe, prepared from material furnished by the Institution, and to be published as a Smithsonian Contribution to Knowledge. He spoke in the highest terms of the character of Professor Coffin as a scientific investigator, an able teacher, and exemplary Christian.

On motion of Hon. Mr. Trumbull, the following resolutions were adopted:

Resolved, That the Board of Regents have heard with profound sorrow of the death of Professor James H. Coffin, of Lafayette College, Easton, Pennsylvania.

Resolved, That in the death of Professor Coffin the Smithsonian Institution has lost a valuable collaborator who has assiduously labored in connection with it in the cause of science for more than twenty years; the country has lost an efficient teacher, an honest, truthful, and industrious man, and the world an original contributor to the science of the day.

Resolved, That a copy of these resolutions be transmitted to the family of the deceased.

The Secretary stated that since the last meeting he had received a telegram from Dr. C. H. Peters, of Clinton, New York, announcing the discovery of a new planet, and that he had availed himself of the facilities offered by the Cable and Western Union Companies, and had sent a dispatch in regard to the discovery to the European observatories.

The Secretary informed the Board that JAMES HAMILTON, of Carlisle, Pennsylvania, recently deceased, had left a legacy of one thousand dollars to the Board of Regents of the Smithsonian Institution, the interest to be "appropriated biennially, either in money or a medal, for such contribution, paper, or lecture on any scientific or useful subject as the secretaries may approve." Action on this subject was postponed until more definite information had been received.*

The Secretary stated that an amendment had been offered in the House of Representatives, but not at the instance of the Institution, to Senate bill 693, "to provide for the further endowment and support of colleges for the benefit of agriculture, &c., &c.," as follows:

"And it is further provided, that the share allotted to the said District of Columbia shall be appropriated to the Smithsonian Institution, to be expended under the direction of the Board of Regents of said Institution, for the support of the National Museum, and in distributing specimens and publications to the colleges named in this act and to other institutions."

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* See Will in Appendix "F" to Journal of Board.

By this bill the Secretary of the Treasury is to invest annually one-fourth of the net amount of sales of the public lands for each year, in United States bonds, bearing five per cent. interest, and is to give to each State and to the District of Columbia an equal share of this interest, provided that the appropriation for any one share shall not exceed in a single year the sum of $50,000.

The opinion was expressed by the Regents that the bill might pass, although it was believed that the income to be derived from the sales of the public lands would be inconsiderable for many years.*

The Secretary stated that the plan of the Smithsonian Institution for increasing knowledge had met with such favor, that other persons, in imitation of James Smithson, had established foundations to advance science, and gave an account of the bequest of the late Professor ALEXANDER DALLAS BACHE; the foundation for lectures by Dr. J. M. TONER, of Washington, and the gift of Professor TYNDALL of the proceeds of his recent lectures in this country.

In each of these cases, Professor Henry had been made the chairman of the boards of trustees appointed to carry out the wishes of the donors.

On motion of General Garfield, it was

Resolved, That a full account of the Bache, Toner, and Tyndall scientific foundations, or trusts, be published in the annual report of this Institution, together with a letter from Professor Tyndall to Professor Henry.†

The Secretary stated that he had transmitted to Congress the annual report of Professor J. W. Powell, relative to his geological and trigonometrical survey of the Colorado of the West and its tributaries.

The Secretary presented his annual report for the year 1872, which was read in part, when, on motion of Dr. Parker, it was

Resolved, That the further reading of the report of Professor Henry be dispensed with, and that it be submitted by the Secretary to Congress.

On motion, the Board then adjourned *sine die*.

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* This bill did not pass the House of Representatives.

† See Appendix "B," "D," "E" to the Proceedings of the Board.

APPENDIX TO THE JOURNAL OF PROCEEDINGS OF THE BOARD OF REGENTS.

A.

PROFESSOR AGASSIZ'S NARRATIVE.

"I was invited by Professor Peirce to take passage in the Hassler, while she was going to the field of her duty on the coast of California, as surveying vessel, provided that my expenses were borne by other parties so that the Coast Survey should not be put to any additional outlay. In consideration of this proposition, my friends in Boston liberally subscribed $20,000 to enable me to make as thorough a series of investigations of animal life and other physical objects as possible, and a little more than this sum was expended.

"We left Boston on the 4th of December, 1871. Our first observations of much interest were upon the Gulf weed, with its well-marked varieties distinguished by differences of stem and leaves. We made large collections of the hydroid communities inhabiting the sargossum, and also of the small fishes, crustacea and other animals finding shelter within its branches. I saw no reason to suppose that the sargossum originates as a floating-plant. On the contrary, all the masses we found, however large, bore marks of having been torn from some attachment. I have already given an account of the nest of the chironectes built of gulf weed, and picked up by us.

"Our first port was Saint Thomas, where we anchored on the 15th of December. Here we made very large collections both of marine and land animals, fish, corals, sea-urchins, star-fishes, and ophiurans, crustacea, shells, lizards, snakes, toads, and frogs, insects and birds. We shipped from Saint Thomas alone eleven barrels and boxes of specimens. Barbadoes was our next collecting-ground. There we made our first cast of the dredge and with remarkable success. The collections forwarded from this port were not so large, but were perhaps more interesting than those of Saint Thomas. The fauna upon the shoals off the Island of Barbadoes strangely resembles that of a past geological time. The comatulæ, pedunculated crinoids, pleurotomariæ, siphoniæ, and cnemidia found upon these shoals recall forms which belonged especially to the Mezozoic ages. This dredging was also rich in corals, sea-urchins, starfish, and ophiurans, and in a great variety of beautiful and rare shells. In some notes handed to me by Count Pourtalés, he says of this same dredging, December 29th and 30th off Barbadoes, about six miles north of Bridgetown, numerous casts of the dredge were taken in depths varying from 17 to 120 fathoms with very rich returns in mollusca, crustacea, echinoderms, polyps, and sponges; many of them were new to science, others either very rare or of much interest on account of their geographical distribution. Pleurotomaria is an example of the former; asthenosoma, ceraiophozus, rhizocrinus, and other echinoderms, of the latter. Deep sea-corals were obtained in considerable quantity, but none appear to be identical with those of the North Atlantic; they also seem to differ more from those of Florida than would have been expected.

"Between Barbadoes and Brazil we had little opportunity for observation, except upon the motions of the flying-fish, the habits and appearance of the physalia, &c. But we had an interesting dredging about a day's sail south of Pernambuco in 500 fathoms, from which we obtained, besides other specimens, a living shell, closely allied to the Pecten paradoxus, as described by Goldfuss. Another cast, about 40 miles east of Cape Frio, in 45 fathoms, gave us a new crustacean, singularly like the ancient trilobites. With reference to temperature off the coast of Brazil, Count Pourtalés' notes give the following details: 'Off Maceio, Brazil, January 17, in latitude 9° 45′ S., longitude 35° 0′ west, the surface-temperature was 80°.5. At 100 fathoms it was 67°; at 485 fathoms; 44°.5; at 556 fathoms, (a few miles farther west,) 42°.5; in latitude 11° 49′ south, longitude 37° 10′ west, surface, 80°.3; at 613 fathoms, 39°. A number of dredgings were taken on the same parallel, but nearer shore, with moderate success.' He adds that subsequent casts of the dredge were taken at various points along the east coast of South America, and in the Strait of Magellan, but almost always in depths less than 50 fathoms where temperature presented no particular interest.

"A delay of three weeks at Rio de Janeiro interrupted our work at sea, but I made use of it to collect largely in the market of Rio de Janeiro and in the neighboring rivers and brooks. The most valuable contribution to science made there, however, consisted in preparations of large numbers of fish-brains, both marine and fresh-water.

"Our next port was Montevideo. Here, however, the quarantine prevented us from entering the city, but I had an opportunity of studying glacial phenomena on a hill in the harbor, where I was allowed to land and where I found erratic material of an unquestionably glacial character, and other evidences of glacial action. Indeed, the most striking fact of all is that the hill itself is a true 'roche moutonnée.' On leaving Rio de la Plate, February 22, we dropped the dredge in some seven fathoms, and it came up laden with valuable specimens. Among other things this cast gave us a large voluta and the egg of a voluta, (of which we found many afterward belonging to different kinds of volutas,) many olivas, serulas, renillas, crustaceans and echinoderms. It is not worth while to record all our dredgings; they were frequent, sometimes very remunerative, and sometimes not at all so. One dredging, of especial value for its rare mollusks and echinoderms, was taken off the mouth of the Rio Negro.

"The next point of great interest was the gulf of San Mathias, at the head of which is the so called Port San Antonio. In this region our collections were very large and various. Among our treasures was a very interesting collection of tertiary fossils in this bay. The cliffs were largely composed of them. My original programme had included a reconnoissance of the rivers Negro and Santa Cruz, and a visit to the Falkland Islands, where I was especially anxious to have a look at the so-called "rivers of stone," believing, as I do, that they are of glacial origin. But the circumstances of the vessel and the lateness of the season made it important to hurry on, and I reluctantly relinquished this part of my scheme. We touched, therefore, at no other point between the gulf of San Mathias and the strait of Magellan, though we paused for a cast of the dredge off the gulf of St. Georges, and were rewarded by some superb star-fishes of immense size, (astrophyton or basket-fish,) besides other valuable specimens.

"We rounded Cape Virgins on the 13th of March, and made our first anchorage at Possession Bay. My published reports have already given some account of our work in this region. The most important results obtained in this locality were Count Pourtalès' discovery that Mount Aymon is an extinct volcano, with a very perfect crater, and forming the nucleus, as it were, of a cluster of smaller volcanoes; beside some less striking geological observations of my own. In the strait of Magellan, and in Smythe's Channel, we passed three weeks, anchoring every night. The zoological results throughout this region were very satisfactory. We made large collections; chiefly marine, of course. But the glacial phenomena here interested me more deeply than the fauna. From the character of the drift, and the constant presence of erratic materials, evidently quite foreign to the soil, and recurring along the Patagonian coast throughout the strait of Magellan, and, as I afterward found, high up on the Chilian coast; from the glacier-worn surfaces on the two sides of the strait, as compared with each other, and on the walls of Smythe's Channel, I satisfied myself that there has been a movement of ice from south northward, preceding all local glacial phenomena, the latter being indeed only the remnant of the former.

"Leaving Smythe's Channel we kept along the coast to the southern end of Chiloe Island, making a run up the gulf of Corcovado in the hope of passing through the archipelago of Chiloe. As we had no charts, however, the captain feared to attempt the inside passage, and after making some collections in Port San Pedro we returned to the open sea, and reached San Carlos de Ancud, at the northern end of the island, on the 8th of March. Here I found again the erratic of the straits and of the Patagonian coast resting upon the breccia of Ancud showing the chronological relation of the volcanic formations of this region to the glacial phenomena. From San Carlos we proceeded with no pause (except at Lota for coal) to the bay of Concepcion. Here we remained a fortnight, and at no point did I make more full and valuable collections. From Concepcion Bay the Hassler went to Juan Fernandez, but as I wished to see something of the geology between the coast and the Andes, I proceeded by land to Santiago. My observations here confirmed my previous impressions as to the glacial phenomena. There is very little evidence of local action proceeding from the Andes, but the whole Chilian valley lying between the coast-range and the Andes proper has been modeled in a south-northerly direction by ice. The valley is, in short, a glacier bottom.

"At Valparaiso we joined the vessel again, and I add some notes from Count Pourtalès concerning temperatures based upon soundings, &c., taken on their voyage to and from Juan Fernandez: 'In the Pacific Ocean soundings were taken between Talcahuana, Chili, and Juan Fernandez. The hundred-fathoms line was found to be about 35 miles off shore. At a distance of 52 miles the depth was 1,006 fathoms. In latitude 35° 30′ south and longitude 75° 11′ west the depth was 2,410 fathoms, temperature 35°. Mud and fragments of a delicate sponge were obtained by the lead; but the dredge-line having been damaged by dampness, parted when hauling up. About two miles north of Juan Fernandez, surface temperature 61°; at 377 fathoms, 41°.5; at 656 fathoms, bottom temperature 61°. The dredge brought up only a few small stones. About three miles off the northwest corner of the same island the depth was 1,144 fathoms, bottom temperature 36°. The dredge brought up nodules of clay, pebbles, worm-tubes, and a small isis. About 25 miles north of the island a depth of 2,214 fathoms was found, with a bottom temperature of 36°; bottom of reddish mud. The dredge was lost again, with a large quantity of line. On the way from Juan Fernandez to Valparaiso a cast of the lead was taken in latitude 33° 33′ south, longitude 77° 2′ west; depth, 1,585 fathoms, bottom temperature 36°; fine white globigerina mud. The hauling up of the line took more than six hours, on account of the constant precautions needed to prevent it from parting. Further attempts were thereafter given up.'

"From Valparaiso we proceeded up the coast, touching at all the principal points, and collecting everywhere. One of our richest collecting-grounds was Parraca Bay, where the fauna was of astonishing richness and variety. The geology was also exceedingly interesting, and I was indebted to Lieutenant Murray Day for a very detailed map of the drift-formation in that region.

"From Payta we struck off to the Galapagos, where we arrived on the 10th of June, and remained till the 19th, touching at Charles Island, Albemarle, Saint James, Jarvis, and Indefatigable Islands. The zoology of these islands is intensely interesting, not only from the peculiar character of the fauna, but also from the physical conditions in which it occurs, all these islands being of such recent volcanic formation as to preclude the idea of a migration of animals from the mainland, and their subsequent adaptation to new circumstances. Our collections in the Galapagos were exceptionally large. Iguanas, both marine and terrestrial, (the two species of amblyrhynchus, first made known by Darwin,) lizards, birds, seals, turtles, besides a great variety of fishes, crustacea, mollusks, and radiates.

"From the Galapagos we proceeded to Panama, where we arrived on the 25th of June. We were detained here for three weeks, but they were very profitable weeks for the collections. The loss of the greater part of our dredging-apparatus between Juan Fernandez and Valparaiso had indeed made dredging in deep waters impossible, but we were the more industrious in collecting in shoal waters along shore and on land. Our next port was Acapulco, where we arrived on the 4th of August, and remained for some days. There, also, we were successful in collecting, and not less so in Magdalena Bay, where we passed two days in drawing the seine. We made no pause between Magdalena Bay and San Diego, where we arrived on the 18th of August. In the Bay of San Diego we added very considerably to our collections. Here, and indeed all along the coast from Valparaiso northward, we found many specimens of cetaceans and selachians. We gathered a large number of cestracions alone.

"Leaving San Diego on the 28th of August, we reached San Francisco on the 31st. Here our voyage ended, but I remained in San Francisco for some weeks for the sake of completing collections formerly made for me in this region. Both there and in Sacramento, with the aid of friends, I succeeded completely in my object.

"It would be impossible for me now to give you more than a very vague and imperfect idea of the extent and value of the collections derived from this voyage. Indeed, I do not fully know it as yet myself, the unpacking being but just begun. The number of barrels and cases, however, forwarded to Cambridge during the ten months of our absence was 265—almost a barrel a day. It would have been simply impossible for me to collect on this scale, but for the cordial assistance I received from the captain and officers of our ship, and, under their direction, from the men, who were always cheerfully ready for the work of the seine and dredge. I was also greatly indebted to Dr. Hill and Dr. White, the physicists of the expedition, who, whenever not engaged in their own duties, were ready to aid me in every way. I should not forget to mention that Dr. Hill made, also, a most valuable and admirably preserved collection of marine plants, gathered at every anchorage where time was allowed for landing. As to the special work of the chemical and physical departments, under the charge of Dr. Hill, ex-president of Harvard, and Dr. White, of Philadelphia, I can give you little information. You could, no doubt, learn all details respecting this part of the work by application to these gentlemen, or to the Superintendent of the Coast Survey.

"My own special party for zoological work consisted of Count Pourtalès, Dr. Steindachner, and Mr. Blake. Count Pourtalès, while sharing in all the general work of the expedition, had special charge of the dredging operations. Dr. Steindachner, although an admirable collector in all departments, was especially engaged in the care of the ichthyological collections. His great knowledge and untiring industry made his assistance invaluable. Indeed, without him I could not have carried out the comprehensive scheme for collecting which I had laid out. Mr. Blake had special charge of the mollusks, and his time was chiefly employed in the drawing of perishable specimens. As I cannot give you an accurate summary of the zoological collections, I will give you a slight sketch of my general scheme, alluded to above, that you may understand their significance as a whole.

"I have endeavored, in the first place, to collect as many specimens of the same species as possible, in every stage of growth and every condition of development, in order to ascertain the range of variation in each species. My second object was to learn the boundaries of the different faunæ, especially along the Pacific coast from the strait of Magellan to California. In this I have included, wherever it was possible, the fishes from the rivers on the western slope of the continent, for comparison with those on the eastern; but this part of my plan was difficult of execution, because I had not the means of collecting in land.

"During our whole journey I was careful to make, or to have made, large numbers of anatomical preparations of such parts of marine animals as can rarely be well studied from alcoholic specimens. The most valuable of these preparations are those of fish brains.

"I need hardly add that we owed the great opportunity for scientific investigation afforded by the voyage of the Hassler to the liberal policy of the Superintendent of the Coast Survey, who is ever ready to combine the larger interests of science with the special work of the survey, when it can be done without detriment to the latter. I should add, however, that the means for making the zoological collections were contributed by gentlemen of Boston, who raised nearly $20,000 for the purchase of alcohol, jars, and other apparatus for collecting on a large scale, and for charges of freight in forwarding the specimens from foreign ports. The latter charges were, however, comparatively small, owing to the liberality of both railroad and steamship companies, of the commanders of our naval forces in various ports, to whom I had special recommendations from the Secretary of the Navy, and of the captains of vessels employed upon whaling voyages or in private mercantile enterprises."

B.

BACHE FUND.

Extracts from the will of Alexander Dallas Bache. Dated March 18, 1862.

Item. As to all the rest and residue of my estate, including the sum of five thousand dollars placed at the disposal of my wife, in case she should not desire to make any disposition of the same, I direct my executors, hereinafter named, to apply the income thereof, after the death of my wife, according to and under the directions of Joseph Henry, of Washington, Louis Agassiz and Benjamin Peirce, of Harvard College, Massachusetts, to the prosecution of researches in physical and natural science, by assisting experimentalists and observers in such manner and in such sums as shall be agreed upon by the three above-named gentlemen, or any two of them, whom I constitute a board of direction for the application of the income of my residuary estate, for the above objects, after the death of my said wife. The class of subjects to be selected by this board, and the results of such observations and experiments, to be published at the expense of my trust estate, under their directions, out of the income thereof, but without encroaching on the principal.

In case of the death or inability to act of all or any of the three gentlemen I have named, in my wife's lifetime, my will is that she shall supply their places in the board of direction by an instrument of writing, either testamentary or otherwise, desiring that in the selection of the persons to administer the income of the trust funds hereby created, she will have regard to the selection of persons whose attention has been directed to the same branches of science as those I have named, and so that each of the departments of physics, mathematics, and natural history shall be represented in the board. In case of any vacancy occurring in the board of direction after its organization, and after the death of my wife, by reason of the death, inability, or refusal to act, or resignation of any of the members, my will is that the surviving or remaining member or members for the time being shall have power to fill vacancies so occurring in the board by the selection of other person or persons to fill such vacancies, and so on, from time to time, as vacancies shall occur.

My intention being that the board of direction shall have power to continue its existence, and to filling all vacancies occurring in their body from time to time.

I direct that a minute of their proceedings be kept, and that the appointment of any member by the board shall be notified in writing to the trustees for the time being of my residuary estate.

In the event of any failure of the board for the time being to direct the application of the income of my said residuary estate, or to continue its existence by filling vacancies occurring in their body, my will is that the application of the income thereof, for the purposes and objects declared in this clause of my will shall be made by the trustees, under the direction of the American Philosophical Society, of Philadelphia.

Extract from the codicil to the will of Alexander Dallas Bache, dated July 15, 1863.

Item. My will is that upon the death of my wife all the rest and residue of my estate shall be paid over to and rest in the corporation of "The National Academy of Sciences," incorporated by act of Congress passed the third day of March, A. D. 1863, whom I hereby appoint trustees in the place of my said executors, under the fourth clause of my said will, to apply the income according to the directions in the said clause contained, to the prosecution of researches in physical and natural science by assisting experimentalists and observers in such manner and in such sums as shall be agreed upon by the board of direction in the said clause named.

My will further is that in case of any failure of the board for the time being to direct the application of the income of my residuary estate, or to continue its existence by filling vacancies occurring in their body, the application of the income thereof for the purposes and objects declared in the said clause shall be made under the directions of the National Academy of Sciences, instead of the American Philosophical Society, of Philadelphia. In all other respects the said application of the income to the purposes aforesaid to be made by the same persons, and under the same rules as I have prescribed in the said clause of my will.

C.

CORCORAN ART GALLERY.

Letter from Mr. Corcoran to the Trustees.

WASHINGTON, *May* 10, 1869.

GENTLEMEN: It is known to you that the building at the northeast corner of Pennsylvania Avenue and Seventeenth street was designed by me for the encouragement of the fine arts, as is indicated by the dedication upon its front.

The work was begun in the year 1859, and was prosecuted with the heartiness naturally incident to such an undertaking, until it was interrupted by the breaking out of the late civil war, when the public exigencies led to the immediate occupation of the building for military purposes; and to these uses it has been devoted ever since, until, being no longer required by the War Department, it is about to be restored to my possession.

It was my cherished hope to have placed the proposed establishment, complete in all its appointments, in successful operation before divesting myself of the title by any formal instrument, but the years which have thus passed away, and the accumulation of other cares and duties, warn me no longer to indulge the pleasing anticipation.

I have, therefore, not doubting your general interest in the subject, taken the liberty of executing to you, as trustees, a deed, which I herewith deliver, sufficiently defining the trusts which I ask you to accept.

In addition to the title to the property itself, you will observe that the instrument vests in you, for the purposes of the trust, the right to receive the rents, wholly unpaid, for the period during which it has been occupied by the Government, now nearly eight years, which will doubtless be adjusted with you, in the absence of any special agreement, upon fair and, perhaps, liberal terms.

As soon as the interior of the building shall have been completed according to the original plans, (which will be placed at your disposal,) for which the rents in arrears will more than suffice, I shall ask you to receive as a nucleus my own gallery of art, which has been collected at no inconsiderable pains, and I have assurances from friends in other cities, whose tastes and liberality have taken this direction, that they will contribute fine works of art from their respective collections.

I may add, that it is my intention to provide further endowment of the institution in such manner and to such extent as may consist with other objects which claim my attention; and I venture to hope that, with your kind co-operation and judicious management, we shall have provided, at no distant day, not only a pure and refined pleasure for residents and visitors at the national metropolis, but have accomplished something useful in the development of American genius.

I am, gentlemen, with great respect and regard, your obedient servant,

W. W. CORCORAN.

To JAMES M. CARLISLE, JAMES C. HALL, GEORGE W. RIGGS, ANTHONY HYDE, JAMES G. BERRET, JAMES C. KENNEDY, HENRY D. COOKE, JAMES C. MCGUIRE, WILLIAM T. WALTERS.

Reply of the Trustees.

WASHINGTON, *May* 10, 1869.

DEAR SIR: We have accepted the trusts confided to us by your deed of this date, in the formal manner indicated by the deed itself.

But we desire, individually and collectively, to add the expression of our personal appreciation of the privilege of endeavoring efficiently to administer such an institution, projected spontaneously by your liberal mind and securely founded by your sole munificence.

While we cannot doubt that, at least in the time of our successors, all your anticipations will be realized, we sincerely hope that you may yourself live to enjoy the high and pure gratification of witnessing the complete success of your generous intentions.

With great respect and warm regard, we remain, very truly, yours,

J. M. CARLISLE.
J. C. HALL.
GEO. W. RIGGS.
A. HYDE.
JAMES G. BERRET.*
JAMES C. KENNEDY.†
HENRY D. COOKE.
J. C. McGUIRE.
W. T. WALTERS.

WILLIAM W. CORCORAN, *Esq.*

Deed of gift and trust of the Corcoran Art Gallery.

This indenture, made this tenth day of May, in the year of our Lord eighteen hundred and sixty-nine, by and between William W. Corcoran, of the city of Washington, District of Columbia, of the first part, and James M. Carlisle, James C. Hall, George W. Riggs, Anthony Hyde, James G. Berret, James C. Kennedy, Henry D. Cooke, and James C. McGuire, of the city of Washington, and William T. Walters, of the city of Baltimore, State of Maryland, of the second part, witnesseth:

Whereas the said William W. Corcoran, in the execution of a long-cherished desire to establish an institution in Washington City to be "dedicated to art," and used solely for the purpose of encouraging American genius, in the production and preservation of works pertaining to the "fine arts," and kindred objects, has determined to convey to a board of trustees the property hereinafter described, to which he may hereafter make other gifts and donations, to be held by said board, and used for the purposes aforesaid: Now, therefore, the said William W. Corcoran, in consideration of the premises, and of the sum of $1, current money of the United States, to him in hand paid by the said parties of the second part, the receipt whereof is hereby acknowledged, hath granted, bargained, and sold, aliened, enfoeffed, and conveyed, and by these presents doth grant, bargain, and sell, alien, enfeoff, and convey unto the said parties of the second part, and the survivors of them, and the heirs and assignees of such survivor—

Lots numbered 5, (five,) 6, (six,) 7, (seven,) and 8, (eight,) in square numbered 167, (one hundred and sixty-seven,) in the city of Washington, and District of Columbia, as the same is laid down and distinguished upon the public plat of said city, fronting 196 feet 9 inches, more or less, on President's Square, and 160.17 feet, more or less, on Seventeenth Street west, together with, all and singular, the buildings, improvements, hereditaments, and appurtenances thereto appertaining, or in any wise belonging, and all the estate, right, title, and interest of the said party of the first part in and to the same:

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*H. C. Matthews has been elected a trustee vice J. G. Berret.

† Prof. Joseph Henry has been elected a trustee vice J. C. Kennedy.

To have and to hold, all and singular, the lots and parcels of ground, and premises aforesaid, with the appurtenances, unto and to the use of them, the said parties of the second part, and the survivors and survivor of them, and the heirs and assigns of such survivor, in trust, nevertheless, and to and for the intents and purposes hereinafter expressed and described, that is to say:

First. That the said parties of the second part shall, without unnecessary delay, after their acceptance of this trust, to be signified by their signing and sealing the memorandum to that effect hereunder written, organize themselves into a permanent board of trustees, with such officers to be selected from their own number as to them may seem necessary or convenient for the orderly management of this trust, and the more efficient attainment of the ends and objects designed by the said party of the first part, as indicated by his general intent, to be gathered from this instrument in all its parts and provisions, and with the same intent and for the same ends and objects, shall make, and as often as may be necessary from time to time, make, alter, amend, repeal, and re-enact, in whole or in part, all necessary by-laws, rules, and regulations in the premises, in execution of, and not inconsistent with the provisions and true intent of this instrument; in all which they shall act by the concurrence of a majority of the whole number of trustees.

Secondly. That when the number of the said original board of trustees, being the said parties of the second part, shall, by death, resignation, or inability, to be ascertained by a resolution of the said board acting by a majority of the whole number, shall have been reduced below the number of nine members, the remaining members shall elect suitable persons, in their discretion, from time to time, as often as may be necessary, so that the board shall always be composed of nine members.

Thirdly. That all the property, real, personal, and mixed, rights, credits, choses in action, or other valuable thing whatsoever hereby conveyed or intended to be conveyed, or which may hereafter be conveyed, given, or transferred and assigned and delivered to the said board of trustees, whether composed of the said parties of the second part or of their successors, chosen and elected as hereinbefore provided, whether in whole or in part, shall be held, managed, limited, used, and devoted to executing the trusts, and giving effect, according to the best judgment of the said board of trustees, from time to time; and all legal rights and titles in the premises shall be taken and held in such manner, and with such legal forms, as shall serve the trusts, intents, uses, and purposes declared or plainly indicated or implied in and by the terms of this instrument.

Fourthly. The property as received and held, or which may be received and held by the said board of trustees, shall be held, used, managed, and disposed of by them and their successors and assigns, whether under this instrument alone or under any act of incorporation hereafter to be procured, for the perpetual establishment and maintenance of a public gallery and museum for the promotion and encouragement of the arts of painting and sculpture, and the fine arts generally, upon such system and with such regulations and limitations as the board of trustees may, from time to time, whether corporate or incorporate, prescribe, limit, and ordain: *Provided always*, That the gallery and museum shall be open to visitors, without any pecuniary charge whatever, at least two days in each week, for such convenient and customary hours as shall be, from time to time, prescribed and made public, and at such other times, not being such public days as aforesaid, such moderate and reasonable fees for admission may be prescribed and received, to be applied to the current expenses of preserving and keeping in proper order the building and its contents.

Fifthly. While the officers necessary or appropriate to the organization of the board of trustees shall be elected from their own number, it is understood that the board shall and may, at its discretion, at all times, employ other persons to be the officers, agents, and servants of the board, for the orderly and efficient management and conduct of the institution.

Sixthly. The system and the appropriate measures for increasing the collection of paintings, statues, and kindred works of art, of which the private gallery of the party of the first part will form the nucleus, and such other voluntary donations as the trustees may from time to time receive, are confided to the direction and judgment of the trustees, as is also the management generally of the institution.

Seventhly. The general intent of the said party of the first part being expressed in general terms in the premises and recitals of this instrument, and further indicated, with certain specifications, in the aforegoing articles, numbered from one to six, inclusive, it is hereby declared that, all and singular, the gifts, grants, conveyances, and assignments herein expressed and set forth are, to and for the trusts, intents, and purposes so as aforesaid expressed, implied, set forth, or indicated, and to none other whatsoever; and that, while it is the intention of the grantor and donor herein that no unruly, technical, or formal breach of, or departure from, the terms and conditions of this trust shall operate as any forfeiture or defeasance in favor of his heirs, or of any claiming in his right, it is hereby declared, and these presents are upon the express and strict condition, that these presents, and every matter and thing hereinbefore contained, and every estate, right, title, interest, and power thereby given, granted, conveyed, and limited, shall cease and determine, and become utterly void and of no effect, whensoever it shall be decreed, adjudged, or declared, by the highest judicial authority having jurisdiction, upon a proper proceeding, in law or in equity, to be instituted by the heirs, devisees, or assigns, of the said party of the first part, that the real estate hereinbefore conveyed shall have been diverted from the purposes of this trust, to be gathered from this instrument in all its parts and provisions, so as substantially to defeat or plainly to be inconsistent with and repugnant to this trust, construed and interpreted in a liberal and sensible spirit; and thereupon, as in case of a breach of a strict condition-subsequent, the heirs, devisees, assigns, or other proper legal representatives in the premises of the said William W. Corcoran, shall be entitled to re-enter upon the said real estate as of his, the said Willim W. Corcoran's, right and title prior to the execution of these presents, and as if the same had never been executed; and in like manner all and every other estate, property, chattel, or valuable thing, the title to which shall have proceeded in the premises from the said William W. Corcoran to the said trustees or their successors and assigns, shall, as far as may be consistent with the rules and principles of law and equity, revert and be revested in right of the said Corcoran or his proper legal representatives therein.

Eighthly. That the said board of trustees may at any time hereafter, in its discretion, apply for and accept an act of Congress incorporating them and their successors, so as to facilitate the execution of this trust, by vesting the same in a perpetual body-corporate, with the like powers and for the same trusts, intents, and purposes herein declared, expressed, or indicated, but for no other trusts, intents, or purposes whatsoever; such act of incorporation to refer to this deed, and to be expressed to be in execution of the trusts thereof; and thereupon the said parties of the second part, and the survivors and survivor of them, or the heirs and assigns of such survivor, shall execute such conveyances as may be necessary to transfer the whole property of this trust to such corporation, upon the trusts of this deed.

And whereas the lots of ground and improvements hereinbefore described and referred to have, by reason of the exigencies of the public service of the United States, been rented and occupied for the public use, without any special contract, but subject to the constitutional provision that "private property shall not be taken for public use without just compensation," which just compensation for the whole period of such occupation by the United States now remains to be paid; and considering the same properly to belong to this trust, as being of the rents, issues, and profits of the ground and buildings which he had heretofore, and as early as the year 1859, devoted and dedicated to the trusts and purposes hereinbefore formally declared: Now, therefore, in consideration of the premises, and of the sum of $1 by the said parties of the second part to him in hand paid, he, the said party of the first part, hath assigned, transferred, and set over, and by these presents doth assign, transfer, and set over unto the said parties of the second part and the survivors and survivor of them, and the executors, administrators, and assigns of such survivor, all and singular the rents, issues, and profits of the lots of ground and improvements hereinbefore described, for and during the whole period of the occupation and possession of the same by the Government of the United States, and all the just compensation which may be due from the United States for the public use of the same, hereby authorizing and empowering the said parties of the second part, or a majority of them, either by themselves or by any substituted attorney or attorneys, to be named and appointed by them, or a majority of them, to acquit and release and receipt for the same in any sufficient legal form of acquittance which may be according to law, as fully as he, the said party of the first part, could personally release and acquit the same.

Which rents, issues, and profits, and just compensation for the public use of the said property shall be received and held by the said parties of the second part for the same uses, intents, and purposes hereinbefore declared; but shall, as far as may be necessary, be applied, before all other objects, to the completion of the interior of said building, and to putting it in a condition to be immediately applied to the primary intents and purposes of this trust, as expressed in the recital in the premises of this deed.

In testimony whereof the said party of the first part hath hereunto set his hand and affixed his seal, the day and year first hereinbefore written.

W. W. CORCORAN.

Signed, sealed, and delivered in the presence of—

JOHN HUNTER.
A. T. BRICE.

We jointly and severally accept the trusts of the aforegoing deed.

Witness our hands and seals the said tenth day of May, eighteen hundred and sixty-nine.

JAMES M. CARLISLE.
JAMES G. BERRET.
W. T. WALTERS.
ANTHONY HYDE.
JAS. C. MCGUIRE.
GEO. W. RIGGS.
HENRY D. COOKE.
J. C. HALL.
JAS. C. KENNEDY.

District of Columbia, County of Washington:

I, Whitman C. Bestor, a notary public in and for Washington County aforesaid, do hereby certify that William W. Corcoran, the party of the first part to a certain deed, bearing date the tenth day of May, A. D. eighteen hundred and sixty-nine, and hereto annexed, personally appeared before me, in the county aforesaid, on the day of the date hereof, the said William W. Corcoran being personally well known to me to be the person who executed the said deed, and acknowledged the same to be his act.

Given under my hand and notarial seal this tenth day of May, eighteen hundred and sixty-nine.

WHITMAN C. BESTOR,
Notary Public.

D.

TONER LECTURES.

Deed of conveyance from Dr. J. M. Toner to five trustees, instituting the Toner lectures at the city of Washington, and establishing a permanent and increasing fund for their support and continuance annually.

This indenture, made this thirteenth day of April, in the year of our Lord one thousand eight hundred and seventy-two, between Dr. Joseph M. Toner, of the city of Washington, in the District of Columbia, of the first part, and the Secretary or chief scientific officer of the Smithsonian Institution, (for the time being Professor Joseph Henry;) the Surgeon-General of the United States Army, (for the time being J. K. Barnes, M. D.;) the Surgeon-General of the United States Navy, (for the time being J. M. Foltz, M. D.;) the president of the Medical Society of the District of Columbia, (for the time being Grafton Tyler, M. D.;) of the second part, all at present residing in said District of Columbia:

Whereas the said party of the first part, believing that the advancement of science—that is, a knowledge of the laws of nature in any part of her domain, and particularly such discoveries as contribute to the advancement of medicine—tends to ameliorate the condition of mankind, hath determined to convey and transfer to the said parties of the second part, and their successors forever, in their several official positions as aforesaid, the hereinafter described real and personal property, amounting in value to about $3,000, ninety per cent. of the interest of which is to be applied for at least two annual memoirs or essays by different individuals, and, as the fund increases, as many more as the interest of the trust and revenue will in the judgment of the trustees justify, relative to some branch of medical science, to be read at the city of Washington at such time and place as the said parties of the second part and their successors as trustees may designate, under the name of "The Toner Lectures;" each of these memoirs or lectures to contain some new truth fully established by experiment or observation, and no such memoir or lecture to be given to the world under the name of "The Toner Lectures" without having first been critically examined and approved by competent persons selected by said trustees for that purpose.

It is further provided, that such of the said memoirs or lectures as may be approved shall be published in such manner and through such channels as said trustees may determine.

And, in order to carry out the intentions hereinbefore expressed, the said party of the first part hath associated with himself the said other parties of the second part, each in his official character as hereinbefore named, with this provision: that upon removal from official position of any one of said parties of the second part, by death or otherwise, his successor in said position shall succeed him as one of the trustees of "The Toner Lectures;" and that upon the death, resignation, or removal of said party of the first part, or his successors, the other trustees surviving shall, within a reasonable time thereafter, elect to succeed him an active and energetic member of the regular medical profession in good standing and practice in the city of Washington, who shall upon his acceptance thereof be and become one of the trustees of "The Toner Lectures." And if the Medical Society of the District of Columbia shall at any time hereafter be dissolved, so that there would no longer be a president thereof, then and within a reasonable time thereafter the other trustees shall elect to succeed the said president, as trustee in this behalf, an active and energetic member of the regular medical profession in this District, in good practice and standing, who shall upon acceptance thereof be and become one of the trustees of "The Toner Lectures;" and so on from time to time, so as to continue to have five trustees, who shall serve without compensation. And to carry out the hereinbefore-expressed intentions these presents are made.

Now, therefore, this indenture witnesseth that the said party of the first part, for and in consideration of the premises aforesaid, and, further, the sum of one dollar, lawful money of the United States, to him in hand paid by the said parties of the second part, at and before the sealing and delivery of these presents, the receipt whereof is hereby acknowledged, hath granted, bargained, sold, aliened, enfeoffed, and conveyed, and doth by these presents grant, bargain, sell, alien, enfeoff, and convey unto the said parties of the second part, the survivor or survivors of them, (and their associates duly elected,) and to their heirs, executors, administrators, and assigns, according to the quality of the estate granted, the following described real estate in the said city of Washington, known and described as being lots numbered six (6) and seven (7) in Clark's recorded subdivision of square north of square numbered three hundred and thirty-four, (334,) and also money and private securities amounting to the sum of $1,100; together with all the improvements, ways, easements, rights, privileges, and appurtenances to the said real estate belonging, or in any wise appertaining, and all the remainders, reversions, rents, issues, and profits thereof:

To have and to hold the said real and personal estate or private securities unto and to the use of the said parties of the second part, together with the said party of the first part, their heirs, executors, administrators, and assigns, in and upon the trusts, nevertheless, hereinafter mentioned and declared—that is, whenever it seems to them that the productiveness of the fund will be increased thereby, to sell the said real estate, and the same to convey in fee simple to the purchaser thereof; and to convert the said personal estate or private securities into money, and the proceeds of said sale and conversion to invest, re-invest, from time to time, and to keep invested in some safe public or private securities in the name and for the use of the trustees of "The Toner Lectures," who shall apply ninety per cent. of the interest thereof annually to defraying the expenses of said "Toner Lectures," and the publication thereof whenever the publication thereof is deemed advisable. The remaining ten per cent. of the said annual interest from the whole fund, as well as any additional gift or unexpended balance at the end of each year, they shall from time to time invest, and the same shall be and become a part of the principal, for the steady increase of the permanent and producing fund of said "Toner Lectures." It is hereby provided that the said trustees shall hold at least one regular meeting annually; keep a correct record, in a book for the purpose, of all proceedings and actions as trustees, with a statement of the expenditures of the revenue, and the condition of the fund, where and how invested; all of which they may, from time to time, at their pleasure make public, and be governed in all matters relating to the general execution of the trusts and intentions herein expressed and declared, and in the investing and disbursing of all trust-moneys, by such rules and regulations as may from time to time be adopted by them for their own government, with this express condition, however: that for the election of any new trustee to fill a vacancy, for the sale of any property or stocks or securities, or the investment of any funds, the approval of a majority of said trustees, in writing or by their votes at a meeting of the trustees, shall be absolutely necessary.

And it is further provided, that in case of the failure at any time of the purposes for which this trust is created, or in case of the failure of the trustees to act for three successive years, or in case of the total failure of the trustees to give effect to this trust, then, and in any such contingency, the fund hereby provided for and created shall revert to the said party of the first part and his heirs or personal representatives.

In testimony whereof, the said party of the first part hath hereunto set his hand and seal on the day and year first hereinbefore written.

J. M. TONER.

Signed, sealed and delivered before Edward Clark, justice of the peace, in the presence of—

S. H. KAUFFMAN,
G. B. GOFF.

We hereby accept the foregoing trust.

JOSEPH HENRY,
Secretary Smithsonian Institution.
J. K. BARNES,
Surgeon-General United States Army.
J. M. FOLTZ,
Surgeon-General United States Navy.
GRAFTON TYLER, *M. D.*,
President Medical Society of the District of Columbia.
JOSEPH MEREDITH TONER, *M. D.*

E.

THE TYNDALL TRUST FOR THE PROMOTION OF SCIENCE IN THE UNITED STATES.

Letter from Professor Tyndall to Professor Henry.

NEW YORK, *February* 7, 1873.

MY DEAR PROFESSOR HENRY: I have made my "will" in due form, and signed it in the presence of witnesses.

My desire and intention in accepting the invitation of my friends were, as you know, to hand over the proceeds to Chicago. But the recovery from calamity is quick in this country, so that Chicago not only does not need my feeble aid, but would be willing of her abundance to add to my wealth.

My disbursements, as I told you, are heavy. Living I have found to be exceedingly expensive in the United States; hence the balance which I am able to hand over to the board of trustees is not so large as I could wish it to be. It, however, amounts to a little more than thirteen thousand dollars.

I have bestowed some care on the accounts, and do not think I carry home with me a single cent of American money. But I carry home what is to me incomparably more precious, and that is the assured good-will of the American people.

The instruments that I take home with me I intend to present to the Royal Institution, where they will be turned to good account. My hands will be then entirely clean, and no foreign element will mingle with the bright memory of the time I spent here.

* * * * * * *

Ever yours, faithfully,

JOHN TYNDALL.

Professor JOSEPH HENRY,
Secretary Smithsonian Institution, Washington, D. C.

THE TRUST.

I, John Tyndall, professor of natural philosophy in the Royal Institution of Great Britain, having, at the solicitation of my friends, lectured in various cities of the United States, find the receipts and disbursements on account of these lectures to be as follows:

I.—*Receipts.*

From Boston, for six lectures	$1,500 00
From Philadelphia, for six lectures	3,000 00
From Baltimore, for three lectures	1,000 00

From Washington, for six lectures	$2,000 00
From New York, for six lectures	8,500 00
From Brooklyn, for six lectures	6,100 00
From New Haven, for two lectures	1,000 00
Total receipts	23,100 00

II.—*Disbursements.*

Before leaving England: Wages of assistants during the preparation of the lectures; work of philosophical instrument maker: new apparatus; sundry items for outfit; traveling expenses of myself and two assistants from London to New York, make a total of £671 6*s.* 8*d.*, which, at the rate of $5.50 per pound, amounts to	$3,692 31
In the United States: Hotel and traveling expenses for myself and two assistants; other expenses incidental to lectures in Boston, Philadelphia,* Baltimore, Washington, New York, Brooklyn, and New Haven, covering a period of four months, plus traveling expenses of myself and my assistant from New York to London, make a total of	4,749 35
Present to Yale's Scientific Club	250 00
Salaries to assistants for four months, £250, which, at $5.50 per pound, amounts to	1,375 00
Making the total disbursements	10,066 66

III.

The total receipts are	$23,100 00
The total disbursements	10,066 66
Making the net proceeds of lectures	13,033 34

As an evidence of my good-will toward the people of the United States, I desire to devote this sum of thirteen thousand and thirty-three dollars to the advancement of theoretic science and the promotion of original research, especially in the department of physics, in the United States.

To accomplish this object I hereby appoint Professor Joseph Henry, Secretary of the Smithsonian Institution, Washington City, D. C., Dr. E. L. Youmans, of New York, and General Hector Tyndale, of Philadelphia, to act as a board of trustees to take charge of the above sum—to carefully invest it in permanent securities; and I further direct that the said board shall, for the present, appropriate the interest of the fund in supporting, or in assisting to support, at such European universities as they may consider most desirable, two American pupils, who may evince decided talents in physics, and who may express a determination to devote their lives to this work. My desire would be that each pupil should spend four years at a German university—three of those years to be devoted to the acquisition of knowledge, and the fourth to original investigation.

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*At Philadelphia I had no hotel expenses, but was most comfortably lodged at the house of my kinsman, General Hector Tyndale. He, I may add, paid his own hotel expenses wherever he accompanied me.

If, however, in the progress of science in the United States, it should at any time appear to the said board that the end herein proposed would be better subserved by granting aid to students, or for some special researches in this country, the board is authorized to make the appropriations from the income of the fund for such purposes.

I further direct that vacancies which may occur in said board of trustees, by death or otherwise, shall be filled by the president of the National Academy of Sciences.

If in the course of any year the whole amount of the interest which accrues from the fund be not expended in the manner before mentioned, the surplus may be added to the principal, or may be expended in addition to the annual interest of another year.

If at any time any organization shall be established, and money provided by other persons for the promotion of such original research as I have in view, I authorize the said board of trustees to exercise their discretion as to co operating in such work from the income of this fund.

In witness whereof I have hereunto set my hand and seal this 7th of February, 1873, in the city of New York.

JOHN TYNDALL. [SEAL.]

In presence of—
C. BURRITT WAITE.
L. E. FULLER.

F.

BEQUEST OF JAMES HAMILTON.

Letter from the executors.

CARLISLE, PENNSYLVANIA, *April* 17, 1873.

DEAR SIR: Inclosed please find printed copy of the last will and testament, and codicil thereto, of James Hamilton, esq., late of this place, deceased, by which we notify you of the bequest made to your board by said last will and testament.

As certain legal questions will have to be decided by the courts before we will feel justified in paying over eleemosynary bequests, it would be well for your board to be represented by counsel.

One of the religious associations have employed Henderson and Hays, who, we understand, are making preparations for a case.

We give you early notice that you may act accordingly, and all legal difficulties be removed at as early a day as practicable.

Our post-office address is Carlisle, Pennsylvania.

Yours, respectfully,

JOSEPH H. STUART,
ABRAM BOSLER,
Executors of James Hamilton, deceased.

Professor JOSEPH HENRY,
Secretary of the Smithsonian Institution.

Extract from the will of James Hamilton, dated November 20, 1871.

"In the name of God, amen. I, James Hamilton, declare this to be my last will and testament, with respect to my personal property:

* * * * * * *

8. I give one thousand dollars to the Board of Regents of the Smithsonian Institution, located at Washington, D. C., to be invested by said regents in some safe fund, and the interest to be appropriated biennially by the secretaries, either in money or a medal, for such contribution, paper, or lecture on any scientific or useful subject as said secretaries may approve."

G.

CIRCULAR SENT WITH SPECIMENS PRESENTED TO INSTITUTIONS.

The following is a copy of the circular sent to foreign museums on the presentation to them of specimens from the collections of the institution; which was alluded to by the secretary in his remarks at the meeting of the Board on the 20th January, 1873:

SMITHSONIAN INSTITUTION,
Washington, D. C., ———, 187–.

DEAR SIR: In behalf of the Smithsonian Institution, we have this day forwarded by ——— the specimens mentioned in the accompanying receipt—a present from the Institution, upon the following conditions:

1. That an acknowledgment be made to the Secretary of the Institution immediately on receipt of the specimens, by signing and returning the accompanying blank.
2. That full credit be given the Institution for the donation, on the labels of the specimens, in published reports, and under all other circumstances.
3. That free access to and use of these specimens be allowed, under the proper restrictions, to all persons engaged in original investigations requiring such material.

4. That suitable returns be made from the duplicates in the collections under your charge, whenever the Institution may desire and call for them.

Very respectfully, your obedient servant,

JOSEPH HENRY,
Secretary S. I.

[To be signed and returned prepaid to the "Secretary of the Smithsonian Institution, Washington."]

———, ———, 187–.

I have received from the Smithsonian Institution, through ——— ———, in behalf of ——— ———, the following collections, subject to the conditions mentioned in the accompanying circular-letter.

——— ———.

GENERAL APPENDIX

TO

THE SMITHSONIAN REPORT FOR 1872.

The object of this appendix is to illustrate the operations of the Institution by reports of lectures and extracts from correspondence, as well as to furnish information of a character suited especially to the meteorological observers and other persons interested in the promotion of knowledge.

EULOGY ON AMPÈRE.

BY M. ARAGO.

[Translated for the Smithsonian Institution.]

Gentlemen: It is my duty to-day, in accordance with an article of the academic regulations dating back to 1666, and which during this long interval of time has always been faithfully executed, to bring before you the labors of one of our most illustrious associates, and at the same time to cursorily glance at his life.

These biographical sketches have not always preserved the same characteristics. Before the judges of the eighteenth century, Fontenelle himself, the ingenious Fontenelle, ventured to refer so briefly to technical points that his eulogy on Newton occupies only about thirty pages in octavo. If you will open this master-piece of delicacy, elegance, and atticism, you will find the celebrated "Treatise on Optics" confined to a few lines, and the title of the "Universal Arithmetic" not even mentioned. In proportion as the sciences progress the ancient boundaries of the academic eulogies should be enlarged, and, in fact, we having at last reached a period when the crowds are largely pressing to expositions of the mathematical and natural sciences with which our vast lecture rooms daily resound, the secretaries of the academy have begun to feel that it is time to rid themselves of the restraints which their illustrious predecessors had imposed upon themselves, that henceforth they might here, at the public sittings, speak of the labors of their associates in the terms hereafter to be used by the historians of the sciences. This new course has already several times received your kind approbation. The idea of departing from it has never even suggested itself to my mind, as indeed, a little reflection would have reminded me, when M. Ampère was removed from our midst, of the impossibility of examining his works, and of making the analysis of his complete encyclopedia, without departing from the usual limits of our eulogies. I must acknowledge, too, that a close intimacy, an intimacy without a cloud for more than thirty years, has also contributed to extend this biography, and to enable me to give importance to certain details that one indifferent to him would have passed by unnoticed. If an excuse be necessary, gentlemen, I will give it to you in a line in which a great poet has defined friendship

"The only passion of the soul in which excess is tolerated."

INFANCY OF AMPÈRE, HIS EXTRAORDINARY MEMORY, HIS PRECOCIOUS TALENTS, HIS FAVORITE BOOKS—HE WRITES ON THE PRIMITIVE LANGUAGE.

Andre Marie Ampère, the son of Jean Jacques Ampère and Jeanne Antoinette Sarcey de Sutières, was born at Lyons, in the parish of Saint Nizier, on the 22d of January, 1775.

Jean Jacques Ampère was well educated, and highly esteemed. His wife was also generally beloved for the uniform sweetness of her disposition and a beneficence, ever on the watch for occasion upon which to exercise itself. A short time after the birth of their son, M. Ampère abandoned commerce and retired with his wife to a small estate in Poleymieux-lez-Mont-d'Or, near Lyons, and here in an obscure village, without the assistance of a teacher, began to dawn, or, as I should say, to be developed that wonderful intellect, the brilliant phases of which I am about to unfold.

The first talent shown by Ampère was that for arithmetic. Before even understanding figures, or knowing how to form them, he made long calculations with the aid of a limited number of pebbles or beans. It may be he had fallen upon the ingenious method of the Hindoos, or, perhaps, his pebbles were combined like the corn strung upon parallel lines by the Brahmin mathematicians of Pondichéry, Calcutta, and Benares, and handled by them with such rapidity, precision and accuracy. As we advance in the life of Ampère we shall find this supposition gradually losing its apparent improbability. To illustrate to what an extraordinary degree the love of calculation had seized upon the young student, being deprived, by the tenderness of his mother, during a serious illness, of his dear little pebbles, he supplied their places with pieces of biscuit which had been allowed him after three days strict diet. I shall not dwell longer on this illustration, as I am far from wishing to give it as an unanswerable or incontestible indication of the future vocation of Ampère. There are children, I know, whose apathy nothing seems able to arouse, and others, again, who take an interest in every thing, amuse themselves with even mathematical calculations without an object. You object to this assertion, charge it, perhaps, with exaggeration, and class numerical calculation with those distasteful tasks which duty and necessity alone can induce one to undertake. My answer is ready, and I will cite, not mere school-boys, but a distinguished savant, who, perceiving my astonishment at seeing him, during a public meeting of the academy, undertake the multiplication of two long lines of figures, said to me at once, "You forget the pleasure it will give me directly to prove this calculation by division."

Young Ampère soon learned to read, and devoured every book that fell into his hand. History, travels, poetry, romances and philosophy interested him almost equally. If he showed any preference, it was for Homer, Lucian, Tasso, Fénélon, Corneille, Voltaire, and for Thomas, whom it is surprising to find, notwithstanding his unquestionable talent in so brilliant a company. The principal study of the young student of Poleymieux was the encyclopedia in alphabetical order, in twenty volumes in folio. Each one of these twenty volumes had separately its turn, the second after the first, the third after the second, and so on to the end, without once interrupting the arithmetical order.

Nature had endowed Ampère, to an extraordinary degree, with the faculty Plato so aptly, and not too extravagantly, describes as "a great and powerful goddess." Thus this colossal work was completely and deeply engraved on the mind of our friend. Each one of us has heard this member of the Academy of Sciences, at a somewhat advanced age, repeat, with perfect accuracy, long passages from the encyclopedia, relating to blazonry, falconry, etc., which a half century before he had read amidst the rocks of Poleymieux. His mysterious and wonderful memory, however, astonishes me a thousand times less than that force united to flexibility, which enables the mind to assimilate, without confusion, after reading in alphabetical order, matter so astonishingly varied as that in the large dictionary of d'Alembert and Diderot. I will ask you to glance with me over the first pages of the encyclopedia. I mention the first pages as I prefer not to choose, that our admiration may be spontaneous.

To begin: The preposition *a* fills the reader's mind with nice grammatical distinctions; *ab* transports him to the Hebrew calendar; *abadir* to the midst of the mythological histories of Cybele and Saturn. The word *abaissement* (depression) carries him at times into algebra, to the reduction of the degrees of equations; into one of the most difficult problems of geodesy and the nautical art, when required to determine the depression of the horizon at sea; and to heraldry, when *abatement* designates the peculiar signs added to the arms of families when necessary to debase their bravery and dignity. Turning the page the article *abbé* will enlighten you as to all that is fickle and capricious in the ecclesiastical discipline. The next word, *abscess*, carries you into surgery. To the description of the anatomical organization of bees, (*alcelles*,) of their mode of living and reproduction, of their habits, of the hierarchical organization of the hive, succeeds almost immediately the explanation of the immortal and subtile discovery of Bradley; of those annual movements of the stars, which, under the name of *aberration*, demonstrate that the earth is a planet. Some lines further on you fall into the *abyss* of cosmogony. *Abacadabra* plunges you into necromancy.

This, then, is the kind of reading that a child of thirteen or fourteen undertook, or rather planned, for himself without finding it too severe a task. I shall have more than one example to give of the strength of Ampère's mind. None, however, more remarkable than the one I am about to relate.

As the modest library of a retired merchant could no longer satisfy the young student, his father took him from time to time to Lyons, where he had access to the rarest books, among others the works of Bernoulli and Euler. When the puny and delicate child first asked the librarian for these works the good M. Daburon exclaimed, "Do you understand the works of Bernoulli and Euler? Reflect, my little friend. These works rank among the most abstruse the human mind has ever produced." "I hope, nevertheless, to be able to understand them," replied the child. "You are aware, I presume, they are written in Latin," added the librarian. This revelation for a moment disheartened our young and future associate; he had not yet studied the Latin language. It is unnecessary to tell you now that at the end of a few weeks this obstacle was removed. What Ampère sought above all things were questions to fathom and problems to solve, even in his earlier studies. The word *tongue* or *language* (*langue*) in the ninth volume of the encyclopedia transported him to the banks of the Euphrates and to the Tower of Babel of biblical celebrity. There he found men speaking all the same language. A miracle related by Moses suddenly produced the confusion. Each tribe spoke from that time a distinct language. These languages mingled and became corrupt, and lost by degrees that character for simplicity, regularity, and grandeur which distinguished the common stock. To discover this original language, or at least to reconstruct it with its ancient attributes, was a problem certainly very difficult, but the young student did not consider it beyond his powers.

Great philosophers had already been engaged in this work. In order to give a complete history of their attempts, it would be necessary to go back to that King of Egypt, who, if we can believe Herodotus, caused two children to be brought up in absolute seclusion with only a goat as nurse, and who then had the simplicity to be astonished that these children should bleat. The word *bécos* proceeding more or less distinctly from their mouths, he considered the Phrygeans, in whose language is found the word *beck*, (bread,) best qualified to be thought the most ancient race of the world.

Among the modern philosophers who have interested themselves in the primitive language, and in the means of restoring it, Descartes and Leibnitz occupy, incontestably, the first places. The problem, as these men of genius treated it, was not merely to improve the musical qualities of modern languages, to simplify their grammar and to banish from them all irregularities and exceptions. They supposed it to consist especially of a kind of analysis of the human mind, of the classification of ideas, and of the complete and exact enumeration of those which should be considered elementary. By means of a language built upon such a foundaion, "the peasants," said Descartes, "would be better judges of the truth of things than are the philosophers now." Leibnitz expressed the same idea in different terms, when he wrote that "the universal language would add more to the powers of reasoning than the telescope to the eye, or the magnetic needle to the progress of navigation."

No one would be so presuming as to affirm that young Ampère treated the question of the universal language with the same comprehensiveness and the same research as Descartes and Leibnitz, but it can be said, at least, that he did not banish its solution, as the first of these philosophers did to the land of romance. Nor did he confine himself as the second did, to dissertations on the marvellous fitness of the future instrument. This instrument he created! Several of Ampère's friends have had in their hands a grammar and dictionary, the fruits of his indefatigable perseverance, containing the almost finished rules of the new language. Some have heard him recite fragments of a poem composed in this new tongue, and can testify to its harmony, the only thing, to tell the truth, of which they could judge, as the meaning of the words was unintelligible to them. Who, besides, among us does not remember the joy experienced by our associate, when, in glancing over the work of a modern traveler, he discovered in the vocabulary of a certain African tribe several combinations, which he had himself formed. It will be remembered that a similar discovery was the chief cause of Ampère's warm admiration for the Sanscrit.

A work which has reached such a degree of advancement, should not be condemned to oblivion. The carrying out by Ampère of an idea of Descartes and Leibnitz will always interest philosophers and philologists in the highest degree. The manuscripts of our brother are fortunately in hands eminently qualified to bring out all that could contribute to the advancement of science and letters.

AMPÈRE'S AFFLICTION DURING THE TERRIBLE REVOLUTION—SUSPENSION OF HIS INTELLECTUAL AND MORAL FACULTIES—RECOVERY—BOTANICAL STUDIES—HIS MEETING WITH THE LADY WHO AFTERWARDS BECOMES HIS WIFE.

The revolutionary tempest in 1793, during one of its most violent convulsions, penetrated as far as the mountains of Poleymieux, and Jean-Jacques Ampère becoming alarmed, in order to escape a danger which his parental and marital solicitude had, perhaps, greatly magnified was guilty of the fatal steps of leaving the country and taking refuge in the city of Lyons, and of there accepting the office of justice of the peace.

You will remember, gentlemen, that after the seige of that city, Collot-de Herbois and Fouché perpetrated there, under the unfortunately specious name of reprisals, the most execrable butcheries. Jean-Jacques Ampère was one of the first of their numerous victims, less on account of holding the position of magistrate during the trial of Chalier, than on account of the hackneyed charge of aristocrat with which he was branded, in the writ of arrest, by the very man, who, a few years later, had engraved on the panels of his carriage, the most brilliant coat of arms, and who signed with the title of duke, the conspiracies he was plotting against his country and his benefactor.

The day he was to ascend the scaffold, Jean-Jacques wrote to his wife a letter full of the most sublime simplicity, resignation and heroic tenderness, in which you will find these words: "Say nothing to Josephine (the name of his daughter) of the unhappy fate of her father; try to keep her ever in ignorance of it. As to my son, *I expect everything of him.*" Alas! the victim deluded himself. The blow was too severe, it was beyond the strength of a young man of eighteen; Ampère was completely paralyzed by it. His intellectual faculties, so active, so ardent and well developed, seemed suddenly to degenerate into a complete idiocy. He would pass whole days mechanically contemplating the skies and the earth, or in heaping up little piles of sand. His anxious friends, fearing his symptoms gave indication of a fatal and rapid decline, tried to entice him into the neighboring woods of Poleymieux, to arouse him, if possible, from this lethargy, where "he was," (I use the very words of our associate,) a mute witness, "an observer without eyes or thought."

This torpor of all feeling, mental and moral, lasted for more than a year, when the botanical letters of J. J. Rousseau falling into his hands, their clear, harmonious language seemed to penetrate into the very soul of the afflicted youth, and in some degree to restore tone to his mind, as the rays of the rising-sun pierce the thick fogs of the morning and bear life into the bosom of the plant that the "numb cold night" had rendered torpid. About the same time a volume, accidentally opened, brought to his notice some lines from the ode of Horace to Lucinius. These lines seemed to convey no meaning to our friend, to him who had merely learned Latin with sufficient accuracy to enable him to read essays on mathematics; but their cadence charmed him, and from this time, contrary to the principles of the moralist who declares the human mind incapable of entertaining at the same time more than one ardent passion, Ampère gave himself up with unrestrained zeal to the simultaneous studies of plants and the poets of the Augustan age. A volume of the *Corpus Poctarum Latinorum* accompanied him in his herborazations, as well as the works of Linnæus, and the meadows and hills of Poleymieux resounded daily with declamations from Horace, Virgil, Lucretius, and especially from Lucian, in the intervals of his dissections of a corolla or the examination of a petal. The *quantity* of the Latin words became so familiar to Ampère, that forty years after, he composed one hundred and fifty eight technical lines in a post-chaise during a tour of inspection of the universities, without once referring to the *Gradus.*

The botanical knowledge he acquired in these solitary studies was as profound as it was lasting. It is my good fortune to be able to cite on this point the unexceptionable and striking testimony of our colleague, M. Auguste de Saint-Hilaire.

The genus Begonia was among the number of those classed by the illustrious de Jussieu under the head of *incertu sedis*, because he had not succeeded in discovering their natural relations. On reaching Brazil, where a large number of the species of this genus is found, M. de Saint-Hilaire examined them with the scrupulous care which gives so much value to all his labors, and discovered their true affinities. Some time after his return to France, M. de Saint-Hilaire, meeting M. Ampère in society, after the usual interchange of civilities was addressed by him in the following terms: "I found yesterday, while walking in a garden, a begonia, and amused myself examining it. With what family do you classify it?" "Since you have examined it, permit me to ask you how you would classify it?" "I would place it in the adjoining group of *ónagraires*," replied M. Ampère. And, in fact, this was precisely the idea a thorough examination, made on the very spot where the plant grew naturally and in the open air, had suggested to M. de Saint-Hilaire. But our two colleagues were guilty of the error of not publishing to the world the solution of a problem whose difficulty is demonstrated by the hesitation concerning it shown by de Jussieu. Ten years later, after his own investigations, Lindley assigned to the genus Begonia the place it should properly occupy—the place first indicated by Ampère and M. Auguste de Saint-Hilaire. Does it not surprise you, gentlemen, to find the name of a geometer thus associated with those of distinguished botanists?

Before the bloody catastrophe of Lyons, Ampère, then but eighteen years of age, made a careful examination of his past life, and discovered, he said, but three prominent points, but three circumstances, whose influence on his future life was important and decided; these were, his first communion, the reading of the eulogy of Descartes by Thomas, and finally—I foresee your surprise—the fall of the Bastile.

From his first communion, our associate dates the existence of fixed religious feeling; from the reading of the eulogy of Descartes, his taste, or rather his enthusiastic love for the study of mathematics, physics, and philosophy; and from the fall of the Bastile, the first exultation of his soul at the names of liberty, human dignity, and philanthropy. The terrible death that snatched from the worthy family of Poleymieux its venerated head was calculated to deaden for a time the faculties of our associate, but there was no change wrought in his convictions. From the moment his intellect was aroused from its slumber, that devotion of mind and heart to the cause of civilization resumed its sway. He scornfully rejected the idea that the fury of a few demons—that crimes—from which he had so cruelly suffered could arrest the progressive march of the world.

The fertile mind with which nature had endowed the student of Poleymieux had been active from his earliest infancy; but such, however, had not been the case with his senses. Those powerful instruments of pleasure and of study were revealed to Ampère at a much later date—at least in all the fullness of their power—and then by a kind of sudden revelation; which, on this account, seems not unworthy of being classed with

Chesselden's history of the man blind from his birth and suddenly restored to sight by the removal of a cataract. Ampère was extremely near-sighted; objects only slightly distant seemed to him but confused and undefined masses. He could form no idea of the pleasure manifested in his presence by the hundreds of people at various times descending the river Saône between Laneuville and Lyons. One day there chanced to be on the boat a traveler as near-sighted as himself, and with glasses which proved to be of a number to suit his eyes. He tried them, and as if by magic all nature assumed a different aspect, the smiling woods, picturesque country, graceful, gently undulating hills, rich, warm, harmoniously blended tints, spoke for the first time to his imagination, and a torrent of tears proclaimed his deep emotion.

Our associate was then but eighteen, and from that time was keenly alive to all the beauties of nature, I have been told that, in 1812, while traveling along the Mediterranean shore of Italy, a view from certain points of the celebrated Corniche on the coast of Genoa threw our friend into such an ecstacy of admiration that instant death in the presence of that sublime picture was all he desired.

Were it needful to show how profound were these impressions, and to what extent Ampère could make them available in coloring the most common-place scenery he desired to embellish, a striking proof may be found in a letter dated January 24, 1819.

At this time our friend was living in a modest house he had purchased at the corner of the streets Fossés-Saint-Victor and Boulangers. The garden, more unpretending still, contained not more than ten superficial meters of unproductive land, recently spaded. Several terraces were succeeded by a steep and tortuous trench, crossed by two or three narrow planks over the deepest parts, the whole surrounded by a very high wall. But, you exclaim, you are describing the damp, gloomy yard of a prison. No, gentlemen; I am describing the plan and appearance of a garden where Ampère, in the middle of January, in the street des Boulangers, was already dreaming of—I had almost said was absolutely seeing—green grass, trees in full leaf, and beautiful flowers, filling the air with their delicious perfumes; and clumps of shrubbery beneath whose shade he could revel in the delightful task of reading letters from his Lyonnese friends, where a bridge thrown over the valley formed a picturesque object.

Pardon me, gentlemen, for having anticipated the order of time—for having selected from the life of our friend the only circumstance, perhaps, where his imagination has not been a source of sorrow to him.

It was not only the emotions of beauty, grandeur, and sublimity with which the hearts of most men are inspired by the view of rural and mountainous scenery to which Ampère had been suddenly awakened. The musical sense was also of sudden birth. In his youth Ampère had given very serious attention to acoustics. He had taken great delight in studying the manner in which waves of air are created and propagated; the different vibrations of a stretched cord; the curious periodic changes of intensity, designated as beats, &c. But music, properly so-called, was to him a sealed book.

The day finally came, however, when certain combinations of sounds were to Ampère something more than mathematical problems—something more than the monotonous tinkling of bells.

In the thirtieth year of his age he accompanied some friends to a concert on one occasion, where, in the beginning, the scientific, animated, and expressive music of Glück was alone performed. The discomfort of Ampère was apparent to all; he yawned, twisted himself, arose, walked about, halted, walked again, without aim or end. From time to time (and this with him was the last stage of nervous impatience) he would place himself in one of the corners of the room, turning his back on the whole assembly. Finally, *ennui*, that terrible enemy our academician had never learned to control, from not having been, as he said, at school in his childhood, seemed to ooze from every pore. Now, the scientific music of the celebrated German composer was succeeded unexpectedly by some sweet, simple melodies; and our associate suddenly felt himself transported into a new world, and his emotions betrayed themselves again by copious tears; the chord uniting the ear and heart of Ampère was struck, and made for the first time to vibrate in unison.

Time made no change in this peculiar taste. During his whole life Ampère showed the same fondness for simple, unaffected songs; the same distaste for scientific, noisy, labored music. Can it be true that in the beautiful art of such masters as Mozart, Chérubini, Berton, Auber, Rossini, and Meyerbeer there are no fixed rules by which to distinguish the very good from the very bad; the beautiful from the hideous? At all events, may the example of the learned academician render us indulgent to the champions of the ruthless war between the Gluckists and Piccinists witnessed by our fathers; and may it induce us to pardon the famous *mot* of Fontenelle, "*Sonate, que me veux tu?*"—("Sonata, what have you to do with me?") As we have just seen, Ampère was almost blind to one of the fine arts until eighteen, and almost deaf to another until thirty. It was during this interval—that is, when about twenty-one—that his heart suddenly opened to a new passion, that of love. Ampère, who wrote so little, has left some papers, entitled *Amorum*, to which he confided, day by day, the touching, artless, and truly beautiful history of his feelings. The first page begins thus; "One day while strolling, after sunset, along the banks of a solitary stream,"—— The phrase remains unfinished. I will finish it with the aid of the memory of some of the early friends of the learned academician.

The day was the 10th of August, 1796.

The solitary stream was not far from the little village of Saint Germain, a short distance from Poleymieux.

Ampère was botanizing. His eyes, in perfect condition to see since the adventure on the barge of the Saône, were not now so exclusively fixed on pistils, stamens, and nerves of leaves that he was unable to observe at some distance two young and pretty girls, of modest demeanor, who were gathering flowers in a vast meadow.

This accidental meeting decided the fate of our associate. Until then the idea of marriage had never even presented itself to his mind. You fancy, perhaps, the idea will quietly take root there, and germinate by degrees; but romantic imaginations do not proceed in this way. Ampère would have been married that very day. The woman of his choice —the only one he ever would have married—was one of those two young girls seen in the distance, with whose family he was not acquainted, of whose name he was ignorant, and whose voice had never reached his ear. But the affair was not so speedily disposed of. It was not until three years afterward that the young girl of the solitary stream and meadow, Mademoiselle Julie Carron, became Madame Ampère.

But Ampère was without fortune, and before giving their daughter to him the parents of Mademoiselle Carron prudently exacted that he should consider the expenses entailed by marriage, and, as is commonly said in the world, establish himself in some business. You will smile, I am sure, to hear that, entirely engrossed by his passion, Ampère allowed them seriously to propose his applying for a position in some shop, where, from morning until night, he would unfold and fold and unfold again the beautiful Lyonnese silks; where his duty would consist principally in detaining the purchasers by engaging them in agreeable conversation, in adhering strictly to a fixed price, but without impatience; in descanting at large on the quality of the fabrics, the taste of the trimmings, and the fastness of the colors.

Ampère, without having taken any part in the discussion, escaped this great danger. Science winning the day in a family council, he left his beloved mountains and proceeded to Lyons to give private lessons in mathematics.

AMPÈRE, PRIVATE PROFESSOR OF MATHEMATICS AT LYONS—CHEMICAL STUDIES—MARRIAGE—A CHOSEN PROFESSOR OF PHYSICS AT THE CENTRAL SCHOOL OF BOURG.

The period now reached in the life of Ampère is marked by more than one memorable event. In this he formed those intimate friendships which stood the test of, without being shaken by, the political crises and disorders of more than half a century. The new friends, animated by the same tastes, met every morning, at an early hour, at the house of one of the number, M. Lenoir, who cannot be described more clearly than as one of the best, gentlest, and most benevolent men who has ever honored the human race. There, in the *Place des Cordeliers*, before sunrise, in the fifth story of the house, seven or eight young men compensated themselves, in advance, for the weariness of the day devoted to business, by reading aloud the chemistry of Lavoisier; a work in which the severity of the method and the clearness of the exposition seemed to vie with the importance of the results, and, which excited in the mind of Ampère the most genuine enthusiasm. The public, a few years later, were surprised to find a very profound chemist in the professor of transcendental analysis in the Polytechnic School; but at that time nothing was known of the private readings in the *Place des Cordeliers* in Lyons. On examining the matter closely, you will find it rare, not to be able to discover in the lives of all men the thread, sometimes highly attenuated, connecting the excellences and tastes of a riper age with the impressions of youth.

The marriage of Ampére took place the 15th Thermidor, in the year VII, (the 2d of August, 1799.) The family of Mademoiselle Carron having no faith in the sworn priests, the only ones then recognized by the civil law, considered it necessary to have the religious ceremony performed secretly. This circumstance, as will be readily understood, made a profound impression on the mind of the learned geometer.

Ampére, now enjoying the fullness of a happiness which alas was destined soon to end, quietly divided his time between the pleasures of family and friendly intercourse and the direction of the mathematical studies of his private pupils. The 24th Thermidor, in the year VIII, (8th of August 1800,) his happiness was increased by the birth of a son, who, though still young, ranks high among the *élite* of French literary writers, and bears with distinction an illustrious name.*

Our friend, now feeling the responsibilities of paternity, could no longer remain satisfied with the precarious living derived from the position of a private teacher; and, obtaining the chair of physics in the central school of the department of Aix, in the month of December, 1801, he repaired to Bourg, with a sad and sorrowful heart at the separation from his family, being forced to leave his wife, then seriously ill, at Lyons.

AMPÈRE'S MEMOIR ON PROBABILITIES.

The studies, plans, and investigations of M. Ampère up to this time had never been given to the public, but remained confined to the limited circle of a few friends.

It seems unnecessary to make any especial exception of the two manuscript memoirs addressed to the Academy of Lyons. Now, however, the young savant began to reveal himself to the public, and, as might be expected, the first occasion was the discussion of a complicated and controverted question of most difficult solution.

The vast field of mathematics embraces on one side abstract theories, and on the other their numerous applications. In the last form they interest the generality of men in the highest degree; whom we see, in all ages, seeking, suggesting, and proposing new applications, founded on observations of natural phenomena or the necessities of every-day life, thus giving the mere amateur the privilege of having his name honorably inscribed on the records of science.

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* Since dead.

Hiero, King of Syracuse, suspecting the honesty of a goldsmith, and desiring, without injuring his crown, to determine the purity of the gold, applied to Archimedes, who thus, through his instrumentality, discovered the fundamental principle of hydrostatics, one of the most brilliant discoveries of antiquity.

The curioso who asked, after having observed the seven bridges between the two branches of the river Pregel and the island of Kneiphof, whether it were possible to cross them successively without passing twice over the same, and he who wished to know how the knight could move over the sixty-four squares of the chess-board without returning twice to the same square, became involved in that geometry of *position*, (glanced at by Leibnitz,) which never makes use of the magnitudes of quantities.

Finally, the speculations of a gambler, belonging to the aristocratic circles, the Chevalier de Méré, first suggested, in the reign of Louis XIV, the calculation of probabilities, or at least directed toward it the attention of Pascal and Fermat, two of the most wonderful geniuses of whom France is so deservedly proud.

This last branch of applied mathematics, although called, by an illustrious geometer, "*common sense reduced to calculation*," was not received without opposition.

Even now public opinion will scarcely admit that analytical formulas are capable of determining the secret of judiciary decisions; or of giving the comparative values of judgments pronounced by tribunals differently constituted; it unwillingly adopts, also, the numerical limits in which have been included the mean result of several series of distinct and more or less concordant observations. When there is a question of an order of problems less subtile, all understanding play require but the most ordinary intelligence to see at a glance that the aid of algebra can here be satisfactorily called in, but even here are met, in the details and applications, real difficulties, requiring the skill of professional men.

Every one readily understands the danger, the stakes being equal, of playing when the conditions of the game give to one greater chances of winning; every one sees, too, at the first glance, that if the chances of the two players are unequal, the stakes should be so too; that if the chances of one, for example, are tenfold those of his adversary, the respective stakes, the sums risked upon the game, should be in the proportion of ten to one; that this exact proportionality of the stakes to the chances is the necessary and characteristic rule, sufficient for all fair play. There are cases, however, where, in spite of the observance of these mathematical conditions, a prudent man would decline to play. Who, for instance, with a million of chances against one in his favor, would risk a million to gain one franc?

In order to explain this anomaly, this disagreement between the results of calculation and the inspirations of common sense, Buffon found it would be necessary to add a new condition to the principles which had seemed to satisfy all but himself. He referred to moral considerations. He remarked that we could not, unless by instinct, prevent ourselves from acknowledging the effects, the loss or profit attached to the proposed games would have on our social position and habits; he observed that an advantage derived from a benefit could not be measured by the absolute value of that benefit, separated from the fortune to which it was about to be added. The geometrical relation of the increase of fortune to the primitive fortune seemed to him to lead to considerations much more in accordance with our mode of life. By adopting this rule you understand at once, for example, that with a million of favorable chances against one single adverse chance, no man, in the full possession of his senses, would consent to play a million francs against one.

The introduction of moral considerations into the mathematical theory of play has undoubtedly detracted from its importance, its clearness, and vigor. It should be regretted, then, that Buffon has used them to reach the conclusion, given in these words: "A long series of chances, is a fatal chain: whose prolongation leads to misery," in less poetical terms, a professional player ends in certain ruin?

This proposition is of the highest social importance, and Ampère was anxious to demonstrate it without borrowing the conditions used by the distinguished naturalist, and the not less celebrated Daniel Bernoulli. Such was the principal object of the work, which appeared in Lyons in 1802, with the modest title of "*Considérations sur la théorie mathématique du jeu*"—"Reflections on the mathematical theory of chances," in which the author proves himself an ingenious and practiced calculator. His formulas, full of elegance, lead to purely algebraic demonstrations of theorems, seeming to require the application of the differential analysis. The principal question, moreover, is found completely solved. The course followed by Ampère is clear, methodical, and faultless. He first established that, between two persons, equally rich, the mathematical principle of Pascal and Fermat, the proportionality of the stakes to the favorable chances should inevitably be the rule of the game; that inequality of fortunes should give rise to no change in this general rule when the players have decided to play but a limited number of games, so few that neither shall be exposed to the total loss of all his fortune; that the question is changed if there should be an indefinite number of games, and a possibility of continuing the play a longer time, thus giving to the richer player an incontestable advantage, which rapidly increases, in proportion to the difference of fortunes.

The disadvantage of one of the players becomes immense if his adversary be very much richer than he, which is always, and very evidently, the case of the professional player, who plays with every one. The whole number of players against whom he plays is to be considered as one single individual endowed with an immense fortune. In games where the chances are equal, and where skill is not required, the professional player may be sure, in due time, of certain ruin—a fact established beyond dispute by the formulas of Ampère.

The empty words "good luck," "chance," "lucky star," "lucky run," can neither hasten nor retard the execution of a sentence pronounced in the name of algebraic authority.

There is a school, calling itself the utilitarian, which has inscribed on its banners three formidable words, *A quoi bon?* "Of what use?" and which, in its bitter warfare against what it calls material and intellectual superfluities, would commit to the flames our fine libraries and splendid museums, and reduce us to the necessity of eating acorns as our fathers did. These adepts would now ask me, How many gamblers have Ampère's calculations reclaimed?

I confess now, in advance, with all humility, and without intending to reflect upon the memory of our colleague, that the work just analyzed in detail has not, perhaps, reclaimed one single individual infected with the inveterate mania for play. The remedy has not taken effect; but can it be proved it has often been applied? Have there ever been professional players sufficiently versed in algebra to understand the formulas of M. Ampère, and to appreciate their perfect accuracy? You would be sadly mistaken, too, if you fancied that the certainty of losing would deter every one from gambling. My doubt seems paradoxical, certainly; I will endeavor to justify it.

Some years since in Paris, I made the acquaintance of a distinguished foreigner, of great wealth, but in wretched health, whose life, save a few hours given to repose, was regularly divided between the most interesting scientific researches and gambling. It was a source of great regret to me that this learned experimentalist should devote the half of so valuable a life to a course so little in harmony with an intellect whose wonderful powers called forth the admiration of the world around him. Unfortunately there occurred fluctuations of loss and gain, momentarily balancing each other, which led him to conclude that the advantages enjoyed by the bank were neither so assured nor considerable as to preclude his winning largely through a run of luck. The analytical formulas of probabilities offering a radical means, the only one perhaps of dissipating this illusion, I proposed, the number of the games and the stakes being given, to determine in advance, in my study, the amount, not merely of the loss of a day, nor that of a week, but of each quarter. The calculation was found so regularly to agree with the corresponding diminution of the bank-notes in the foreigner's pocket-book that a doubt could no longer be entertained.

Did the learned gentleman renounce gambling forever? No, gentlemen; for a fortnight only. He declared that my calculations had completely convinced him; that he would no longer be the ignorant tributary of the gaming-houses of Paris; that he would continue the same kind of life, but without the mad excitement of hope and fear that led him on before. "I shall no longer," he added, "be in ignorance of the fact that the 50,000 francs of my fortune consecrated to play will pass into other hands. I am resigned to it perfectly; but I shall no longer be, in the eyes of the world, the dupe of an absurd delusion. I shall continue to play, because the superfluous 50,000 francs expended in any other way would be unable to excite in my feeble frame, undermined by suffering, the lively sensations alone aroused by the various combinations, fortunate and adverse, displayed every night on the green carpet!"

A little reflection will prove that these words are not a mere paraphrase of the well-known witticism of a celebrated statesman: "After the pleasure of winning, I know none so great as that of losing."

It would be doing injustice to mathematical science if I attempted to defend its formulas against the reproach of not having foreseen that the passionate storms, resulting from play, which sweep the bosom would not always prevail over the soft and touching gratification men of means might daily enjoy in applying their wealth to the alleviation of human misery. The passions, although of divine institution, as a woman of the world once said, are so protean that it would be a vain effort on the part of mathematics to entwine them in their regular and methodical meshes. But, again, if science has failed in such a task, the misfortune is shared by the dialectics of the moralist, the eloquence of the pulpit, and even by the sweet persuasions of the poet. I have read somewhere that Colbert on one occasion wished to dissuade the monarch whom he had never failed to serve with devotion and ability from undertaking a certain war. Boileau, promising to aid him in his effort, addressed to Louis XIV that beautiful letter containing a seductive picture of the delights of peace, and, among other remarkable passages, the lines on the Emperor Titus, that live in the memory of every one:

Qui rendit de son joug l'univers amoureux;
Qu'on n'alla jamais voir sans revenir heureux;
Qui soupirait, le soir, si sa main fortunée
N'avait par ses bienfaits signalé sa journée.

Who led the world captive, yet charmed with its chain,
  From whom no one could part without joy in his breast,
Whose evenings were saddened and shadowed with pain,
  When closing a day that his hand had not blest.

These lines touched the heart of the king. He caused them to be read aloud to him three times, then ordered his horse to be saddled, and straightway joined the army.

AMPÈRE'S POETICAL COMPOSITIONS.

Ampère composed, in his early youth a tragedy on the death of Hannibal, in which are to be found some excellent poetry and the noblest sentiments. I must add here, that during his sojourn in the principal town of the department of Ain, his mind was not so completely absorbed in science, that he could give no time to the study of literature and the higher kinds of poetry. Take for example a letter handed to me recently, by our learned colleague M. Isidore Geoffroy, from Bourg, and read by him, the 26th germinal, year XI, before the Emulation Society of Ain, beginning thus:

Vous voulez, donc, belle Emilie,
Que de Gresset ou d'Hamilton
Dérobant le leger crayon,
J'aille chercher dans ma folie,
Sur les rosiers de l'Hélicon,
S'il reste encor quelque bouton
De tant de fleurs qu'ils ont cueillies;
Souvent mes tendres rêveries, etc.

Then, wouldst thou, fairest Emily,
   Have me steal the pencil free
Of Gresset or of Hamilton;
   And wend my way to Helicon,
To see if on the rose trees there
Some buds remain, they well could spare
   From all the flowers they have culled
To glean some bud they well could spare
   To be for thy soft bosom pulled.

I am not sure that the beautiful Emily was not one of those imaginary beings so lavishly invested by poets with perfections of their own creation; but the friends of Ampère will remember that the eminently good, beautiful and distinguished woman, who had united her destiny with his, had often inspired his muse; many will recall some lines, whose first appearance excited no little sensation;

Que j'aime à m'égarer dans ces routes fleuries,
Où je t'ai vue errer sous un dais de lilas;
Que j'aime à répéter aux nymphes attendries,
Sur l'herbe où tu t'assis, les vers que tu chantas.
* * * * * * *
Les voila ces jasmins dont je t'avais parée,
Ce bouquet de troëne a touché tes cheveux, etc.

'Tis sweet my wandering steps to lose
   Along the path of flowers,
Where lighter feet were wont to choose,
   Their way mid lilac bowers:
And on the turf that thou hast prest,
   To breathe forth once again,
The song that made the wood nymphs blest,
   Thine own enchanting strain.

They lie around, those jasmins fair
   With which I deck'd thy brow;
That privet, it hath touched thy hair,
   To me 'tis sacred now.

A certain mathematician once made the sad mistake of publishing some verses, faultless as to measure and rhyme, but without other merit. A witty lady, hearing them read, remarked that the author of the lines, after the example of M. Jourdain, *wrote prose without knowing it.* Many writers, called poets, though never having passed through a course of geometry, have fallen into the same error. A satirical remark, however, cannot revive the so often silenced question of the chilling influences of scientific studies. Such names as those of

Plato, Lucretius, Descartes, Pascal, Haller, Voltaire, and of J. J. Rousseau, effectually settle it; and should the discussion be ever renewed, Ampère's letter, several lines of which I have just quoted, could be cited with advantage, and his name added to the distinguished list.

You may think, perhaps, gentlemen, and not without reason, that I have lingered too long over the poetical works of Ampère. I would like to remind you of the four lines, not more, addressed to the celebrated Ninon de l'Enclos by the great geometer Huygens, and so uncharitably revived by literary writers. The law of retaliation authorizes me to contrast, with this unlucky quatrain, the scientific errors of different poets. Boileau might figure in our polemics, if we thought it advisable, as but a sorry votary of the learned Urania, proved by these two lines from his Satire on Women:

> Que l'astrolabe en main, une autre aille chercher,
> Si le soliel est fixe *ou tourne sur* SON AXE—

"Let another try to discover, with the astrolabe in hand, whether the sun is fixed or whether it *turns on its axis.*"

The worthy Abbé Delille did not prove himself more orthodox, when he attributes, in a passage in his inaugural, the more brilliant coloring, rapid growth, and greater fragrance of the tropical productions to the fact that the *Sun warms them from a nearer point.*

This remarkable instance of scientific knowledge is worthy of being ranked with that conveyed in the line of a man, who surely had never doubled Cape Horn, nor even read Cook's voyages; a line which should have suggested to the writer to knock from beneath him the Parnassian ladder —

> From the frozen to the burning pole!

But it seems to me, gentlemen, that within these walls instead of looking for poets who are not savants, it would be better to cite savants who have been something of poets.

AMPÈRE, SUMMONED TO PARIS, BECOMES TUTOR, AND AFTERWARDS PROFESSOR OF ANALYSIS, AT THE POLYTECHNIC SCHOOL.

Lalande and Delambre were delighted with the analytical work of the young professor of Bourg on the calculation of probabilities; they summoned him to Paris, and gave him the position of tutor in the Polytechnic School, where he acquitted himself with great credit, but not without encountering many trials, results of the retired life he had previously led. Badly advised by friends ignorant of the customs of the place, Ampère made his appearance before his classes, in a school almost military, dressed in a fashionable black coat, miserably made by one of the most unskillful tailors of the capital; and for several weeks this unlucky garment was a source of such distraction to more than a hundred young men that they were unable to attend to the treasures of science falling from the lips of the savant.

The tutor, fearing the characters on the black-board are not sufficiently distinct to be seen by the more distant members of the class, very naturally endeavors to remedy the evil by increasing their size. In the discussion which usually follows the lesson, with the young men gathered around him, several of them, in a spirit of mischief, exaggerating their want of sight, induce the benevolent professor to increase the size of the figures by degrees, until the immense black-board, far from affording room for intricate calculations, can scarcely give place to a few figures.

Absorbed finally in the elucidation of a difficult theory, in the heat of demonstration he mistakes the rubber covered with chalk for his handkerchief. The account of this certainly very innocent mistake, amplified and magnified, passes from rank to rank, until, when he appeared again before them, he was no longer the learned analyst of their admiration, but the innocent object of their mirth; his moments of abstraction, so eagerly watched for, being but signals for ridicule too long anticipated to be willingly relinquished.

You now know, gentlemen, the rocks upon which the knowledge and zeal of the worthy professor were so often wrecked.

PSYCHOLOGY, METAPHYSICS, AMPÈRE'S PASSION FOR THEM.

At the same time as geometrician and metaphysician, Ampère, from his first arrival in Paris, moved in two distinct societies; the only feature of resemblance being the celebrity of their members. In one. were to be found the first-class of the ancient Institute, the professors and examiners of the Polytechnic school, and the professors of the college of France. In the other, Cabanis, Destutt de Tracy, Maine de Biran, Degérando, &c.

Here the effort was to fathom and analyze the mysteries of the mind. There this mind, in such measure as nature has bestowed it, and as education has improved and enlarged it, was each day producing new marvels. The psychologists sought the paths that lead to discovery; the geometers, chemists, and physicists were actually making discoveries. Without devoting too much time to the manner in which it was done, they discovered sometimes the analytical formulæ now actually including the laws of the movements of the stars; sometimes the subtile rules of molecular actions, which, while giving us the clue to the causes of a great number of natural phenomena, throw light upon the operations of art, and developed national wealth. They made themselves masters finally, of the new properties of light, electricity and magnetism, which have given so much brilliancy to the first years of this century. Vibrating between these two schools, if the term may be allowed, Ampère's ardent imagination daily endured the severest trials. I am not able to say, with any certainty, how the exact sciences were regarded by metaphysicians; but I know that geometers and chemists held in very slight esteem, investigations purely psychological.

This error, for I am very much inclined to believe this was an error, will be somewhat lessened in the eyes of those who will take into consideration that in metaphysics every thing is connected, linked and bound together like the meshes of the most delicate tissue, in such a manner that a principal cannot be detached from the whole number of definitions, observations, and hypotheses from which it emanates, without losing most of its apparent importance and perspicuity. When Ampère, still warmly excited by the conferences he had just held with the psychologists, strove madly, I mean without preparation, to hurl *l'émesthese*, for example, into the midst of a reunion of geometers, physicists, and naturalists, when still under the influence of his enthusiasm, he maintained that an obscure word, or at least one not understood, contained the most beautiful discovery of the century, was it not natural he should encounter skeptics? This would have been of no consequence if the extreme amiability of our associate had not allowed the skeptics whose role is to ridicule, to usurp the place of those whose doubts were serious.

I find in the manuscript correspondence, to which I have access through M. Bredin, that Ampère had contemplated while in Paris the publication of a book which he intended to call "*Introduction to Philosophy.*"

The famous anathema of Napoleon against ideology did not discourage him; it seemed to him rather to contribute to the propagation of this kind of studies than to its suppression. Our associate continued to elaborate his *Theory of Relations*, his *Theory of Existence*, of *Subjective and Objective Knowledge*, and of *Absolute Morality.*

He considered himself incapable of throwing sufficient light on subjects so difficult to treat without submitting them to animated verbal discussions. Unfortunately the so ardently desired opportunities were not to be found in Paris at that time. Maine de Biron had returned to Berjerac, and among the remaining inhabitants of that immense capital, not one seemed to feel any interest, from a metaphysical point of view, in subjective, objective, and absolute morality. Ampère then turned his eyes in the direction of the friends of his youth, and resolved to return for a short time to Lyons. The terms of the visit were strictly arranged; a certainty of *at least four afternoons a week* devoted to discussions on ideology, a formal promise that each day should be read and examined with a view to correction in composition and perspicuity, the subjects of each day's study. Although I have not at hand the text of the replies received by Ampère I have every reason to believe they were far from giving him satisfaction. "How wonderful is the science of psychology!" he wrote to M. Bredin, "and most unhappily for me, you no longer feel an interest in it, is it necessary, besides to deprive me of all earthly consolation, he said, to know we no longer sympathize on metaphysical subjects. * * * About the only thing which interests me, you no longer think as I do. * * * This creates a frightful void in my soul."

Ampère's friends in Lyons had found his psychology somewhat dry and minute. They tried to induce him to return to the exact sciences, but our associate replied to them in a lyrical strain, "How can I abandon a country full of flowers and fresh, running waters; how give up streams and groves for deserts scorched by the rays of a mathematical sun, which, diffusing over all surrounding objects the most brilliant light, withers and dries them down to the very roots? * * * How much more agreeable to wander under flitting shades than walk in straight paths, where the eye embraces all at a glance, and where nothing seems to fly before us to incite us to pursue!"

It was my desire to seek the fresh groves discovered by Ampère and to try to persuade you to enter them with me; but, alas! accustomed by your advice and example to prize above all things in matters of science, straight and well-lighted paths, my dazzled eyes found but profound darkness where the piercing eyes of our ingenious friend were privileged to see brilliant semi-tints. Without the guide of Ariadne's clue it would be in vain to attempt Ampère's manuscripts, I should be afraid, I must acknowledge, of being forced, as Voltaire was formerly, to place at the end of each metaphysical proposition the two letters N. L., traced by the style of the Roman magistrate, when the cases seemed too obscure to allow a well-grounded judgment. But *non liquet*, (it is not clear,) too frequently repeated, in spite of perfect sincerity, would have worn an air of affected modesty to be avoided at any price.

Is my extreme diffidence to be condemned? It would not be difficult to justify it by pointing alone to the arrogant contempt each psychological school casts upon its rival, and that through the organ of its most eloquent propagandists.

Listen to what I will read to you from the lectures of one of its most celebrated teachers, Laromiguière, "What is a science which has neither fixed nor invariable methods; which changes its nature and its form at the will of those who profess it? What is a science which is no longer to-day what it was yesterday; which by turns boasts as its oracles Plato, Aristotle, Descartes, Locke, Leibnitz, and so many others whose doctrines and methods seem to have nothing in common? In a word, what is a science, not only whose existence, but whose possibility is questioned?"

But Ampère bespoke in advance all my reserve when he exclaimed, These last have only uttered what is eminently just and true, when in comparing the true metaphysicians of the schools of Kant and Schelling with the followers of Reid and Dugald Stewart, they said, the last are to the first what good cooks are to chemists.

I will leave to the most competent judges of future times to assign to Ampère a place amongst psychologists. Nevertheless, I may now affirm that the wonderful powers of penetration and the rare faculty of reaching wide generalizations from minute detail must have distinguished his metaphysical researches, since it shone with such brilliancy in works on physical mathematics the most solid, or, if you prefer, the most generally recognized and the most indisputable foundation of his scientific fame at the present day. Ampère, in metaphysics, as nearly as the subject would permit, approximated to the experimental method. It certainly is not from his mouth that proceeded those incredible words attributed to a psychologist, "I despise you as I do a fact."

He, on the contrary, held facts in the highest favor. He showed great fertility in combining them with his theories. When, though rarely his efforts in this line were fruitless, theories were immediately changed or abandoned. Amongst my hearers there are probably some to whom these words will recall both the first ideas of our associate on the instinct of animals and the manner in which he modified them. The circumstances of this sudden change seem to merit being preserved.

Among the most prominent of the many vexed metaphysical questions is, whether animals possess the powers of reasoning. or are solely guided by instinct—a question which will, perhaps, be better understood by presenting it in these terms: Must we, with Aristotle, concede only feeling and memory to the brute creation? Is it true they are without the faculty of comparing their actions and drawing conclusions? Ampère, avowing himself on this point a decided peripatetic, in the presence of several of his friends, one of them related, in opposition to his views, the following anecdote:

"Being overtaken one night, not far from Montpelier, by a violent storm, I took refuge in an inn, in the first village I found on my road. The death of a lean chicken was the immediate result of this unexpected visit. The cook, placing the almost fleshless fowl on the spit immediately tried to seize a terrier, which, when introduced into a rotatory drum of quite large dimensions, under the mantel-piece, was to perform the office of moving the combinations of weights, springs, and cogged wheels now found in the humblest kitchen, but then, in the center of France, a great rarity. The terrier absolutely refused to perform the duty assigned him; he would yield neither to blows, threats, nor caresses. So much firmness, resolution, and courage attracting my attention, I inquired if the poor beast were making his first trial. Poor beast! some one replied, ill-naturedly and roughly, he does not deserve your pity, on my faith; for such scenes take place every day. Do you know why this *fine gentleman* refuses to turn the spit? Because he has decided, in his head, that he and his comrade must divide the labors of roasting exactly regularly between them. I now remember he was the last to turn the spit, and he now concludes *this is not his turn to work.*

"The words, *it is not his turn now*, seemed to me to include a world of meaning. At my request the stable-boy was sent into the street to fetch the second dog. This one showed the most exemplary docility;

the rotatory drum received him, and he would soon have finished the task if, wishing to complete the experiment, I had not caused him to be removed in order to give the refractory dog a new trial. The refractory dog, *whose turn had now come*, obeyed the first signal of the cook, entered the rustic turn-spit without resistance, and went to work like a squirrel in its cage.

"Does it not follow from this, my dear Ampère, that dogs can have the consciousness of the just and the unjust, leading them to lay out a rule for themselves, and to endure corporal punishment rather than allow any violation of it?"

Ampère's features so keenly expressed the interest he took in the recital that you might have fancied he was about to exclaim with Lactance, "Except in matters of religion, the brute creation share all the advantages of the human race." However, our associate did not press the matter as far as the *Christian Cicero*. While modifying his former views on instinct, he merely admitted that animated beings, taken in the aggregate, exhibit every possible degree of intelligence, from the lowest up to that which, to adopt the expression of Voltaire, might inspire with jealousy the *familiars of Jove himself*.

I shall not leave this subject without giving another example to show, in spite of his extreme animation in discussion in the main, how true and tolerant Ampère was, and how free from the malevolent passions that unconceived ideas and conceit usually bring in their train. In some manuscript notes of a professor of Lyons, M. Bredin, with whom Ampère studied the metaphysical doctrine of the absolute, I find these exact words: "*Very animated discussions daily arose between us*, and in them originated that *holy and indissoluble friendship which has so firmly united us*."

A writer of romance would fancy he was doing violence to probability by placing friendship among the possible consequences of heated discussions. A presumption so unparalleled could only be tolerated in the land of fable.

MATHEMATICAL LABORS OF AMPÈRE.

Such a man as Ampère often puts the self-love of his biographer to a severe trial. I was obliged just now to shrink from psychological researches whose importance and depth I could not reach; and here again I am forced to confess that an intelligible analysis, in common language, of the works of our associate on pure mathematics, is beyond my powers. Nevertheless, as in these works figure the memoirs which, after the death of Lagrange in 1813, opened the doors of the Academy to our friend, they ought to be mentioned, if only by their titles.

The adventurous mind of Ampère was always fond of questions that the fruitless efforts of twenty centuries had pronounced insoluble; he was never happier, if I may be allowed the expression, than when upturning the principles of science. I must acknowledge I was not a little astonished not to find him struggling with the quadrature of the circle. This inexplicable hiatus, in the youth of our associate, has just been filled. A manuscript note from the secretary of the Academy of Lyons apprises me that, on the 8th of July, 1788, Ampère, then thirteen years of age, addressed to that learned body a paper relating to the celebrated problem just mentioned. Later during the same year he submitted to the examination of his compatriots an analogous memoir, entitled "*The rectification of any arc of a circle less than the semi-circumference.*" These memoirs have not reached us. If the manuscript note sent to me can be relied upon, young Ampère, not only did not think the problem insoluble, but flattered himself he had almost solved it. Scruples, respected by me without being shared, demanded the sacrifice of this anecdote. It certainly would have been a very small sacrifice, but I did not consider it consistent with my duty to make it. The scientific weaknesses of men of a very high order of intellect are lessons quite as useful and profitable as their successes, and the biographer has no right to cover them with a vail. Is it quite certain, too, that there is anything here to excuse or conceal; that a geometer need blush for efforts made in his childhood, or even at a riper age, to square the circle geometrically? To sustain, however, such a proposition, we have only to recall the fact that antiquity presents to us, as deeply engaged in this problem, Anaxagoras, Meton, Hippocrates, Archimedes, and Apollonius; and to these we may add the modern names of Snellius, Huygens, Gregory, Wallis and Newton; and, finally, that amongst those whose sagacity the quadrature of the circle has set at defiance—I mean who have been involved by it in palpable errors there are many who have, in other respects, rendered genuine service to science; for example J. B. Porta, the inventor of the camera-obscura; then Grégoire de Saint Vincent, the Jesuit, to whom we owe the discovery of the wonderful properties of hyperbolic spaces terminated by asymptotes; Longomontanus, the astronomer, &c., &c.

If your mind is engrossed with the idea that, in order to justify their efforts to square the circle, others will cite hereafter, to their advantage, the attempts of a child of thirteen, I reply unhesitatingly—for my academic duties bring me frequently in and personal relations with the squarers of the circle—that authorities have absolutely no weight in their eyes; that they have long since entirely separated themselves from everything that bears or has borne the name of geometer; that Euclid himself, in his principal theorems—for example, that of the square of the hypotheneuse—seems to them scarcely worthy of trust. If a mania—I was on the point of saying a furor which manifests itself especially in spring, as proved by experience—could ever be amenable to logic, it would be necessary, in order to battle it successfully, to distinguish more carefully than has ever yet been done the various aspects under which the problem of the quadrature of the circle ought to be considered. An example of cure under my own eyes might give me some confidence in this mode of treatment.

The first, according to date, of all the mathematical memoirs of Ampère, printed after his arrival in Paris, relates to a question of elementary geometry. This memoir, presented to the Academy of Lyons in 1801, appeared in the publication of the correspondence of the Polytechnic School in the month of July, 1806. A few words will suffice to describe the end Ampère proposed to himself.

There is in elementary geometry a proposition so evident that it may properly be regarded as an axiom. It is this:

If two lines situated in the same plane are parallel, or, in other words, if, prolonged indefinitely, can never meet; and if a third line, forming an angle at any point with the first of the two parallels, be indefinitely extended from the point of intersection, it will cut the second. No one can feel a doubt about this theorem, although all the efforts of the most celebrated geometers, the Euclids, the Lagranges, the Legendres, &c., to add to its natural evidence by way of demonstration, properly so-called, have been fruitless.

The geometry of solid bodies, had offered, up to the present time, a proposition whose truth was quite as evident, and that, nevertheless, had never been demonstrated. I refer to the equality of volume of symmetrical polyhedrons. Two oblique polyhedrons have the same base situated on a horizontal plane; one is entirely above the plane, the other entirely below. Their faces are similar and of the same length; moveover, their inclinations correspond exactly to a common base. To give the same idea in different words—one of the two polyhedrons being considered as an object, the other would be its image reflected on the plane of the common base, if that plane were a mirror.

The object of Ampère's treatise is to demonstrate the equality of these two polyhedrons; and it can be affirmed that, on this point, in the science of geometry there is nothing more to desire.

In 1803 M. Ampère addressed to the institute a very finished work, which, however, was not given to the public until much later, (1808,) entitled "*Treatise on the advantages to be derived, in the theory of curves, from due consideration of osculatory parabolas.*" We also find a treatise by Ampère dated the 26th florial year 11 which was published in the first volume of the collection of the foreign savants of the Academy of Sciences. This is its title "*Investigations on the application of the general formulas of the valculus of variations to problems in mechanics.*"

The formulas of equilibrium, given by the immortal author of analytical mechanics, have a form analogous to that of the equations that the calculus of variations furnishes for the determination of the maxima and minima of integral formulas. Ampère thought that this similitude of form, previously noticed by Lagrange, would afford him the means of avoiding, in the solution of questions in statics, the troublesome integration by parts. The analogy is not as complete as might be thought at first sight. The ordinary formulas require to be changed in order to be used in the solution of problems of mechanics. Ampère gives these transformations and applies them to the ancient problem of the catenary.

This problem, which consisted in determining the curve formed by an inextensible chain of uniform weight when attached to two fixed points, is famous under more than one name. Galileo tried, ineffectually, to solve it. His conjecture that the curve sought might be a parabola, was found false, in spite of all the paralogisms accumulated by Pères Pardies, and de Lamis to prove its accuracy to the singular adversary who brought to oppose them proofs from mechanics. In 1691 Jaques Bernoulli challenged the scientific world with the same problem. Only three geometers had the courage to take up the gauntlet—Leibnitz, Huygens, and Jean Bernoulli, who, we may remark in passing, at this time, evinced the first symptoms of his jealousy of his master, benefactor, and brother; thus demonstrating that the love of fame is capable of becoming the most ungovernable, most unjust, and blindest of the passions. The four illustrious geometers were not content to give the true differential equation of the curve; they also pointed out the consequences deduced from it. Everything now seemed to authorize the belief that the subject was exhausted; but this was a mistake. The treatise of Ampère contains, in fact, new and very remarkable properties of the çatenary and its development. There is no small merit, gentlemen, in discovering hiatuses in subjects explored by such men as Leibnitz, Huggens, and the two Bernoullis. I must not forget to add that the analysis of our associate unites elegance with simplicity. Ampère gave, moreover, a new demonstration of the celebrated mathematical relation known as Taylor's theorem, and calculated the finite expression, neglected when the series are arrested at any term whatsoever.

Called to the chair of mathematics at the polytechnic school, Ampère could not fail to seek a demonstration of the principle of virtual velocities, disengaged from the consideration of infinitesimals. Such is the object of a treatise published in 1806, in the thirteenth number of the journal of the school.

Whilst candidate for the position left vacant by the death of Lagrange in 1813, Ampère presented to the academy, first: *General considerations on the integrals of equations of partial differences;* and afterwards, *an application of these considerations to the integration of differential equations of the first and second order*. These two treatises give superabundant proof that analysis, in its most difficult form, was perfectly familiar to him.

Ampère was not inactive after becoming a member of the academy; he busied himself with the application of analysis to the physical sciences. Amongst these productions we may cite:

1. *Demonstration of the laws of mariotre*, read at the academy January 24, 1814.

2. *Demonstrations of a new theory, from which can be deduced all the laws of refraction, ordinary and extraordinary;* read at the academy March 27, 1815.

3. *A memoir on the determination of the curved surfaces of luminous waves in a medium whose elasticity differs in three dimensions;* read at the Academy of Sciences August 26, 1828.

AMPÈRE'S RESEARCHES IN THE SCIENCE OF ELECTRO-DYNAMICS.

Amongst the works of our friend there is one which excels all the others; it constitutes, in itself, a beautiful science, and its name, "Electro-dynamics," will ever be inseparably linked with that of Ampére. Instead of presenting to your thoughts twenty different subjects in succession, permit me to concentrate them for a time on the vast and teeming conception of our friend, happy if I succeed in disengaging it from any appearance of obscurity and ambiguity it may have presented up to this time, and thus show the elevated rank which will entitle it, with the most beautiful discoveries of the age, to the gratitude of posterity. While so many of the ancient and modern sciences were making rapid and momentous progress, the science of magnetism had remained almost stationary. We have known that, for centuries at least, bars ot iron, and more especially of steel, freely supported, turn toward the north. This curious property has given us the two Americas, Australia, the numerous archepelagoes, and the hundreds of isolated islands of Oceanica, &c.; it is to it this, in cloudy and foggy weather, the mariner, plowing the mighty oceans, has recourse, to guide and direct his ship; no truth in physics has had results so colossal. Nevertheless, until the present time, nothing had been discovered regarding the nature of the peculiar modification undergone by a bar of neutral steel during the mysterious—I had almost said, cabalistic—operations which transform it into a magnet.

The whole phenomena of magnetism, the diminution, the destruction, the inversion of the polarity of the needle of the compass, occasioned sometimes on ships by violent discharges of lightning, seemed to establish some intimate connection between magnetism and electricity. Nevertheless, the labors, *ad hoc*, undertaken at the request of several academies in order to develop and strengthen this analogy, led to so few decisive results that we read, in a programme by Ampére himself, printed in 1802:

"The professor will demonstrate that the electrical and magnetic phenomena are owing to *two different fluids*, which act independently of each other."

Sciences had reached this point when, in 1819, the Danish physicist, Œrsted, announced to the learned world a fact, wonderful in itself, but more so especially from the consequences deduced from it; a fact the memory of which will be transmitted from age to age, as long as science is honored amongst men. I will try to give a clear and exact idea of this most important discovery.

The voltaic pile is terminated at its extremities, or, if you prefer as an expression more suitable, at its two poles by two dissimilar metals. Let us suppose, for example, the elements of this wonderful apparatus to be copper and zinc; if the copper is at one of the poles the zinc will inevitably be at the other. The battery, with the exception of some slight traces of tension, is, or at least seems to be, completely inert as long as the extreme poles are not put into communication by means of a substance conductive of electricity. A metallic wire is generally used to connect the two poles of the battery, or, which amounts to the same thing, to put the apparatus in action. This wire is then called the *conjunctive wire.*

A current of electricity passes along the whole length of the conductor, and *circulates uninterruptedly* through the closed circuit, resulting from the union of the wire and the battery. If the battery is very powerful, the current will be equally so.

Physicists had for a long time known how to impart to an insulated metallic wire a large quantity of electricity in repose, or electricity of tension, as it is called in treatises on physics; they also know how to transmit electricity along wires not insulated in *very large quantities;* but in this case the passage was sudden and instantaneous. The first means of combining intensity with duration in currents of electricity is furnished by the galvanic battery, with which a discharge, more powerful than could be produced by the largest ancient machines for the millionth part of a second, is here given for hours together. Does the conjunctive wire, the wire along which a quantity of electricity *passes uninterruptedly*, acquire, in consequence of this movement, any new properties? To this question the experiment of Œrsted replies affirmatively in the most striking manner.

Let us place a wire of a certain length, of copper, silver, platina, or any other metal without appreciable magnetic action, above a horizontal compass, and *parallel to its needle.* The presence of the wire will have no effect. Make no change in the first arrangement, but join, either directly or by intermediary long or short wires, the two extremities of the parallel wire to the two poles of a voltaic pile; or in this way let us transform the insulated wire into a conjunctive wire, along which a permanent current of electricity passes, and at that very instant the needle of the compass will change its direction; if the battery be feeble the deviation will be inconsiderable; but if the battery be very strong, notwithstanding the action of the earth, the magnetic needle will form an angle of nearly 90° with its natural position.

I have supposed the conducting wire *above* the magnetic needle, placed *below* the phenomenon would be the same with regard to quantity, qut exactly opposite as to the direction of the deviation. The conjunctive wire *above* would impel the north pole of the needle toward the west; the deviation would be toward the east when, the conditions being the same, the wire is *below*. It is necessary to remark here that the wire preserves absolutely none of that deviating power the moment it ceases to be a conducting wire, or to join the two poles of the battery. It would indicate a total want of scientific perception not to understand how extraordinary and important are the results I have just announced; not to observe with surprise an imponderable fluid imparting for the moment to the slender wire along which it passes, properties so powerful.

These properties, studied in their specific characters, are not less wonderful.

Even a child knows it would be useless to try to turn a horizontal lever around a pivot on which its center rests by pushing or pulling it lengthways—I mean, following the line leading to the center of rotation. The force must necessarily be transverse. The perpendicular to the length of the lever is, no matter in what direction, that which requires the least force to create a given movement. The experiment of M. Œrsted is directly opposed so these elementary rules of mechanics.

Please then to remember, when the forces developed by the passage of the electrical current in each point of the conducting wire are found to correspond vertically with the axis of the needle itself, either above or below, the deviation is at its maximum. The needle remains at rest, on the contrary, when the wire is presented to it in a direction nearly perpendicular.

Such is the strangeness of these facts that, in order to explain them, various physicists have had recourse to a continued flow of electrical matter circulating round the conducting wire at right angles to it, and producing the deviations of the needle by way of impulse. This was nothing less, on a small scale, than the famous vortices contrived by Descartes to account for the general movement of the planets around the sun. Thus a physical theory which had been abandoned for more than two centuries was recalled by the discovery of Œrsted.

We have already mentioned the important remark of the celebrated Danish physicist, that the deviations of the needle of a horizontal compass approach nearer and nearer 90 degrees in proportion to the increase of the power of the battery during the connection of the two poles by the wire. Feeble batteries, on the contrary, produce only scarcely sensible movements. What is the part played by that mysterious power, seeming to reside in the arctic regions of the globe, to attract magnetic bodies in a certain way, and repel others? What part does it perform in lessening the deviations when the battery has little power?

Ampère perceived the importance of this question at the very first glance; he saw it was not a mere nice and subtle refinement without bearing; he understood that the solution of the problem would stamp with characteristic features the forces brought into play by the experiment of Œrsted; but how get rid of the attraction of the earth; how eliminate it; how intercept it? I see some smile at my question, and hear them exclaim, Do not mariners cover with pieces of canvas or pea-jackets the iron cannon in the neighborhood of the compass, whenever they wish to obtain exactness in their bearings? Screens, then, ought effectually to furnish the means of protecting the needle from terrestrial magnetism. As to that, a glass sphere, inclosing the compass, would answer.

A single word will dispel this illusion. No substance, thick or thin, has yet been discovered through which magnetic action, like that of gravity, does not exert its full force, without any abatement. The custom of covering cannon, balls, and anchors, with sails, tarred or untarred, or with anything else, to prevent their action on the compass, belongs to the thousand and one usages recorded in treatises on navigation before science had diffused its light around it. Even when exposed, such usages diffuse and perpetuate themselves, and are the blind powers which govern the world. The researches of Ampère did not absolutely require (which, in fact, would have been an impossibility) that his apparatus should be completely free from the attraction of the earth; it was sufficient that this attraction should not counteract the movement of the needle; and this simple reflection became the ray of light that guided the illustrious physicist, and gave rise to a kind of compass never before thought of.

To understand the invention of Ampère by which a magnetic needle could be so arranged as to be free to obey the action of a galvanic current, and undisturbed by the magnetism of the earth, suppose an ordinary dipping-needle apparatus so placed that its graduated circle shall be perpendicular to the magnetic meridian of the place, and then so inclined to the horizon that the graduated circle and the needle within it shall be at right angles to the direction of the magnetic dip of the place where the experiment is made. In this condition the magnetism of the earth will act perpendicular to the direction of the needle and be opposed by the pivot on which the lower point of the axis rests. It will therefore be free to take any position in the plane of the divided circle which an extraneous force may give it. Ampère was therefore quite right in calling his new instrument an *astatic* compass.

Ampère's astatic needle, placed before a conducting wire, takes a direction exactly perpendicular to that wire, neither one second more nor less; and, a very remarkable circumstance, a very feeble electricity produces as much effect as a current of sufficient intensity to reduce metals to a state of incandescence. Here, then, is one of those simple laws that science loves to record, and the mind receives with confidence, and before which false theories will inevitably disappear.

The discovery of Œrsted reached Paris through Switzerland. At our weekly meeting on Monday, September 11, 1820, a member of the academy from Geneva repeated before you the experiment of the Danish savant. Seven days later, on the 18th of September, Ampère presented to you a much more general fact than that of the physicist of Copenhagen.

In that short interval of time he had conjectured that two connecting wires, two wires traversed by electrical currents, would act on each other; he had devised extremely ingenious arrangements to make these wires movable without the necessity of detaching the extremities of each from the respective poles of their batteries. He had embodied these conceptions in instruments capable of acting; he had, in fact, reduced his wonderful idea to a decisive experiment. I do not know whether the vast field of physics ever exhibited so beautiful a discovery conceived and consummated with so much rapidity.

This brilliant discovery of Ampère may be summed up in these words: Two parallel connecting wires attract each other when the electricity traverses them in the same direction; on the contrary, they repel each other when the electric currents move in opposite directions.

The connecting wires of two batteries similarly placed, of two batteries whose copper and zinc poles respectively correspond always, then attract each other. There is in the same way always repulsion between the connecting wires of two batteries when the zinc pole of one is opposite the copper pole of the other.

It is not a necessary condition of these singular attractions and repulsions that the wires in operation should belong to two different batteries. By bending and rebending a single connecting wire such an arrangement may be made that two of its portions, opposite to each other, may be traversed by the electrical current either in the same or in opposite directions. The phenomena, then, are absolutely identical with those which result from currents proceeding from two distinct sources.

The phenomena of Œrsted, from their origin, had been called, very appropriately, electro-magnetic. To those of Ampère, in which the magnet plays no distinct part, the more general name of electro-dynamics has been applied.

The experiments of the French savant did not escape at first those criticisms which envy reserves for all things possessing novelty, importance, and a future. Men were unwilling to see in the attractions and repulsions of these currents anything more than a hardly appreciable modification of the ordinary electrical attractions and repulsions known since the time of Dufay. On this point the replies of our friend were prompt and decisive.

Bodies similarly electrified repel each other; similar currents attract each other. Bodies in an opposite condition of electricity attract each other; unlike currents repel each other.

Two bodies similarly electrified repel each other from the moment of contact; two wires traversed by similar currents remain together like two magnets, if brought into contact.

No subterfuge in the world could resist this close argumentation.

Another class of critics embarrassed our associate more seriously. These last acted apparently in a charitable spirit. To believe them, they invoked with all their hearts, but without hope, the solution of a great difficulty; it pained them deeply, they said, to see the glory with which these new discoveries would have surrounded the name of Ampère vanish so rapidly. This is somewhat the manner in which the insurmountable difficulty was formulated. Two bodies which separately have the property of acting on a third cannot fail to act on each other. The connecting wires, according to the discovery of Œrsted, act upon the magnetic needle, then two connecting wires ought to influence each other reciprocally; hence, the movements of attraction and repulsion, when brought together, are deductions, necessary consequences, of the experiment of the Danish physicist; hence, it would be wrong to rank the observations of Ampère among the primordial facts which open to science entirely new paths.

Action and reaction are equal. There was in the phraseology just cited a false air of that incontestible principle of mechanics which misled many minds. Ampère replied by challenging his adversaries to deduce with any degree of plausibility the resultant direction (*le sens*) of the mutual action of two electrical currents; although he made the demand with much spirit, no one acknowledged himself defeated.

The infallible means of reducing this violent opposition to silence, of sapping its objections to their foundation, was to cite an example where two bodies which would act separately on a third would, nevertheless, not act on each other. A friend of Ampère remarked, that magnetism exhibited a phenomenon of this kind. He said to the benevolent antagonist of the great geometer: "Here are two keys of soft iron; each of them attracts this compass; if you cannot show that, placed near each ther, these keys attract and repel each other, the point of departure of all your objections is false."

From that moment the objections were abandoned and the reciprocal actions of electrical currents took definitely the place belonging to them among the most beautiful discoveries of modern physics.

Once disembarrassed of the charges of originality and priority, always more painful when implied than when openly made, Ampère sought with zeal a clear, vigorous, and mathematical theory, which would embrace, under a common head, not only all the phenomena of ordinary magnetism, but also those of electro-dynamic phenomena. The investigation bristled with all kinds of difficulties. Ampère overcame them with methods on which the genius of invention shone at every step. These methods will remain as one of the most precious models in the art of investigating nature; of seizing in the midst of the complex forms of phenomena the simple laws which govern them.

Dazzled by the *éclat*, grandeur, and fertility of the law of universal attraction—that immortal discovery of Newton—persons little conversant with mathematics imagine that, in order to introduce the planetary movements into the domain of analysis, it would be necessary to surmount obstacles a thousand times greater than those met by the modern geometer, when he wishes, with the assistance of mathematics, to follow in all their ramifications the various phenomena discovered and studied by physicists. However general this opinion may be, it is not the less an error. The smallness of the planets, when compared to the sun; the immensity of the distances; the almost spherical form of the celestial bodies; the absence of all matter capable of offering any sensible resistance in the vast regions where the elliptical orbits are described, are so many circumstances extremely simplifying the problem, and bringing it within the abstractions of rational mechanics. If, instead of the movements of the planets—I mean of distant bodies capable of being considered reduced to simple points—the only guide had been the phenomena of attraction of irregular polyhedrons, acting on each other at short distances, the laws of universal gravity would remain yet to be discovered.

These words will suffice to give an idea of the real obstacles which render the progress of mathematical physics so slow. No one need, therefore, be surprised to learn that the propagation of sound, or of luminous vibrations; that the movement of the light waves ruffling the surface of liquids; that the atmospheric currents caused by irregularities of pressure and temperature, etc., are much more difficult to calculate than the majestic course of Jupiter, Saturn, or Uranus.

The phenomena of terrestrial physics Ampère proposed to unravel were certainly among the most complex. The attractions and repulsions observed between conducting wires resulted from the attraction and repulsion of all their parts. Now, to pass from the whole to the determination of the numerous and different elements which compose it, or in other words to the investigation into the manner in which the mutual actions of two infinitely small parts of two currents vary, when their relative distances and inclinations are changing, offered unwonted difficulties.

All these difficulties have been overcome. The four conditions of equilibrium, which have rendered so much assistance to the author in developing phenomena, will be called the laws of Ampère, as the three great consequences, deduced by that celebrated genius from the observations of Tycho, are called the laws of Kepler.

The oscillations, turned to so great profit by Coulomb in the measurement of small magnetic or electrical forces, imperatively exact that the bodies for experiment should be suspended by a single film without torsion. The conducting wire cannot be placed in such a position, as it would be in danger of losing its virtue unless in permanent communication with the two poles of the battery.

Oscillations give very exact measurement, but coupled with the express condition of being numerous. The conducting wires of Ampère never fail to be at rest after a very small number of oscillations.

The problem appeared truly insoluble, when our associate perceived he could reach his object by observing different conditions of equilibrium between conducting wires of certain forms placed one before the other. The choice of these forms was the essential point; and it is here the genius of Ampère displayed itself in the most marked manner.

He first enveloped with silk two equal portions of the same conducting wire; he bent this wire so that its two covered portions should be in juxtaposition, and traversed from opposite sides by a current from the same battery; he was satisfied then that this system of two equal but opposite currents exercised no power over the delicately suspended conducting wire, and thus proved that the attractive force of a given electrical current is perfectly equal to the force of repulsion it exercised when the direction of its course is mathematically inverted.

Ampère then suspended a very moveable conducting wire, exactly between two fixed conducting wires, which being traversed from the same side by one and the same current ought to repel the intermediate wire; one of these fixed wires is straight, the other bent and twisted, presenting a hundred small sinuosities. The communication necessary to give play to the currents being established, the moveable intermediate wire will stop exactly between the two fixed wires, and if moved from its position will return itself to the same place. From this it follows that if a straight connecting wire and a sinuous connecting wire, though their unfolded lengths may be very different, exercise powers exactly equal if they have extremities common to both.

In a third experiment Ampère established undeniably that no closed current whatever could cause a circular portion of connecting wire to turn round an axis perpendicular to that one arc passing through its center.

The fourth and last fundamental experiment of our associate is an instance of equilibrium, involving three suspended circular circuits whose centers are in a straight line, and whose radii are in a continuous geometrical proportion.

Our associate made use of those four laws to settle what he had allowed to remain arbitrary in his analytical formula, conceived in the most general terms imaginable to explain the mutual action of two infinitely small elements of two electrical currents.

A skillful comparison of the general formula with the observation of the four cases of equilibrium shows that the reciprocal action of the elements of two currents is exercised in the direction of the line uniting their centers; that it depends on the mutual inclination of these elements, and that it varies in intensity in the inverse proportion of the squares of the distances.

Thanks to the profound researches of Ampère, the law, which governs celestial movements, the law, extended by Coulomb to the phenomena of electricity at rest or in tension, and then though with less certainty, to magnetic phenomena, becomes one of the characteristic features of the powers exercised by electricity in motion. The general formula, which gives the value of the mutual actions of the infinitely small elements of currents, once understood, the determination of the combined actions of limited currents of different forms becomes a simple problem of integral analysis. Ampère did not fail to follow out these applications of his discoveries. He first tried to discover how a rectilinear current acts on a system of circular closed currents, contained in planes perpendicular to the rectilinear current. The result of the calculation, confirmed by experiment was, that the planes of the circular currents, would, supposing them movable, arrange themselves parallel to the rectilinear current. If like transversal currents pass over the whole length of a magnetic needle, the cross direction which, in the experiment of Œrsted, completed by Ampère, seemed an inexplicable anomaly, would become a natural and necessary fact. Is it not evident, then, to all how memorable would that discovery be that would rigorously establish the fact that to magnetize a needle is to excite, to put in motion around each molecule of the steel, a small, circular, electrical vortex? Ampère fully realized the wide reach of the ingenious generalization that had taken possession of his mind; and he hastened to submit it to experimental proofs and numerical verifications, which, in our day, are the only processes considered entirely demonstrative.

It seemed very difficult to create an assemblage of closed circular currents capable of great mobility. Ampère confined himself to an imitation of this composition and form, by causing a single electrical current to circulate through a wire enveloped in silk, and coiled like a helix in very compact spires. The resemblance between the effects of this apparatus and those of a magnet was very striking, and encouraged the illustrious academician to devote himself to a difficult and minute calculation of the actions of closed circuits perfectly circular.

Starting from the hypothesis that like currents exist around the particles of magnetic bodies, Ampère, recognized, in elementary actions, the laws of Coulomb. These laws treated with the most consummate skill by an illustrious geometer have explained all the known facts of the science of magnetism; the hypothesis of Ampère represents them with equal accuracy.

The same hypothesis, finally applied to the investigation of the action which a rectilinear connecting wire exercises over a magnetic needle, leads analytically to the law that M. Biot has deduced from extremely nice experiments.

If, with the almost entire body of ancient physicists, it is thought advisable to consider steel as composed of solid molecules, in each of which exist two fluids of opposite properties, fluids combined, and neutralizing each other when the metal is not magnetic, fluids more or less separated when the steel is more or less magnetized, the theory will cover all that is known at present, even in the most subtle numerical particularities of ordinary magnetism. This theory is silent, however, with reference to the action of a magnet on a connecting wire, and still more silent, were it possible, as to the action that two of those wires exerçise upon each other.

If, on the contrary, we take, with Ampère, the action of two currents for the primordial fact, the three classes of phenomena will depend on one principle, one single clause. The ingenious conception of our associate possesses thus two of the most salient characteristics of a true laws of nature, simplicity and fertility.

In all the magnetic experiments attempted before the discovery of Œrsted the earth had acted like a large loadstone. It was to be presumed, then, like a magnet, it would act on electrical currents. Experiments, however, had not justified the conjecture. Calling to his aid the electrodynamic theory and the talent for inventing apparatus, so brilliantly displayed by him, Ampère had the honor of filling the inexplicable hiatus.

For several weeks native and foreign physicists crowded the humble study in the street Fossée-Saint-Victor to witness with amazement a connecting wire of platina take a definite direction through the action of the terrestrial globe.

What would Newton, Halley, Dufay, Æpinus, Franklin, and Coulomb have said if it had been announced to them that a day would come when, in default of a magnetic needle, navigators would be able to guide their vessels by observing electrical currents, electrified wires?

The action of the earth on a conducting wire is identical in all the circumstances presented by it, with that which would proceed from an assemblage of currents, having its seat in the depths of the earth, south of Europe, and whose movements would be like the diurnal revolutions of the globe from west to east. Let it not be said, then, that, the laws of magnetic action being the same in the two theories, it is a matter of indifference which to adopt.

Suppose the theory of Ampère true, and the earth, as a whole, inevitably a vast voltaic pile, creating currents moving in the direction of the diurnal revolution; and the memoir in which is found this magnificent result will take rank, without disadvantage, with the immortal works which have made of our globe a simple planet, an ellipsoid flattened at the poles, a body formerly incandescent in all its parts; incandescent still down in its depths, but retaining on its surface no appreciable trace of this original heat.

It has been asserted that the beautiful conceptions of Ampère, of which I have just given a detailed analysis, were coldly received; it has been said that the French geometers and physicists showed themselves little inclined either to recognize or study them; that the academy, with the exception of one single member, swayed by its prejudices, refused for a long time to yield itself to unexceptionable proof.

These charges reached the public through an eloquent and eminently honorable organ. I cannot, therefore, pass them by without notice.

The experiments of Ampère, from their first appearance, were the object of the severe criticism just cited, and, soon after, of universal admiration. The only competent and capable judges of intricate and scientific calculations of nice theoretical deductions of whose almost boundless range I have just tried to give you an idea, were of necessity geometers. Now is it just to say the French geometers found fault with our distinguished associate, when, a short time before the discovery of electro-dynamics, M. Savary was found completing a very important point of that theory; when M. Lionville was trying to simplify its bases and render them more rigorous; when, in the compilation of the most difficult parts of his grand memoir Ampère found in M. Duhamel an earnest collaborator?

Is it true that Ampère's formula displayed no features likely to occasion astonishment amongst geometers? Would not the curiosity of those most familiar with Newtonian theories be awakened by observing the introduction of general expressions of the mutual action of these elements, trigonometrical quantities relative to the respective inclinations of the infinitisimal elements of the electrical currents? Was not some hesitation natural when new theories seemed to depart so completely from beaten paths? There was nothing extraordinary, exceptional, nor extravagant on the part of the savants who experienced this hesitation. A few years before the transversal waves of light of Fresnel had created the same doubts, the same uncertainty, and in the minds of the same individuals, although they seemed a still more evident consequence, a more direct and immediate translation and one easier to verify, of the facts of interference exhibited by polarized rays.

Let us not complain in general terms of the worship rendered usually by men to the ideas under whose influence their minds have been developed. In such cases it is just, natural, and proper to make no change of views without a thorough investigation. From a scientific point of view, the criticisms and difficulties, so frequently overwhelming innovators, are substantially useful. They arouse the idle to triumph over indolence; even jealousy, with its cruel and hideous acuteness, becomes an incentive to progress. It can be relied upon to discover gaps, blemishes, and imperfections that even the most careful author allows unavoidably to escape him. The control it exercises over him who disdains not to profit by it, is worth ten-fold that of the best friend. It commands no gratitude either, for its services are involuntarily rendered; and on the other hand it would be a weakness to sympathize too warmly with the vexations it causes in men of genius; for fame and peace of mind rarely bear each other company. He who is ambitious of high place in the world of matter or of ideas, must expect to find as adversaries those already occupying the highest places. Small minds aim at trivial objects, and alone are privileged to reach, at will, insignificant points, whose possession no one dreams of disputing with them.

AMPÈRE TAKES PART IN A CELEBRATED DISCUSSION BETWEEN GEORGE CUVIER, AND GEOFFROY SAINT-HILAIRE ON THE UNITY OF STRUCTURE IN ORGANIZED BEINGS.

This discussion rested on some very nice considerations. If it were desired, for instance, to trace the resemblance between the arrangements of the viscera of a cephalopodic mollusk and those of man, it would be necessary to fancy the latter bent backwards from the line of the navel, so that the pelvis and lower limbs should be joined to the nape of the neck; it would be necessary, moreover, to imagine man walking on his head. Other comparisons required that one of the two animals should be reversed like a glove; that the bony structure should pass from within to without, that the enveloped should become the envelope, etc., etc. The members of the mathematical department of the college could take no part in this subtle debate; they were satisfied to be attentive listeners. Ampère alone threw himself headlong into the arena. But it was found that the views so warmly opposed by Cuvier, and so decidedly sustained by our honorable colleague, Geoffroy Saint-Hilaire, were those entertained by Ampère in 1803.

Cuvier, the learned secretary of the academy, when concluding his course on the history of the sciences of the nineteenth century, was naturally led to allude to the German school known under the name of *Philosophers of Nature.*

The principles of the philosophers of nature, at least those referring to the unity of structure in animals, appearing to him erroneous, he undertook to oppose them. Ampère was one of the auditors of our illustrious colleague. If, as at the Normal Conventional School, the students had the right to challenge the professors, each lecture of Cuvier's course would assuredly have ended in an animated and instructive debate; but the regulations imperiously forbade such an innovation. Ampère was not the man to be discouraged by difficulties. Custom denying him permission to speak in the arena where Cuvier was unfolding his views, openly without leaving the precincts of the college founded by Francis the First, if not on the same day, at least during the same week, when delivering his course on *Mathésiologie*, Ampère broadly announced himself, with reference to the chief point of philosophic zoology, the declared adversary of the first naturalist of Europe. In each of his lectures he gave a minute and detailed criticism of the preceding lecture of Cuvier. But in return, Cuvier regularly used an analysis of Ampère's argument, made by his brother Frederic, who attended the course on *Mathésiologie*, as the text for each succeeding one of those lectures, whose glorious memory will long be preserved by the College of France, and in which shone in the same high degree, his talent for explaining, his knowledge of facts in detail, and must it be avowed, his art of rendering sarcasm cutting without overstepping the limits of a well-bred critic. Each week Ampère would seem felled by the blows of the new

Hercules, and each succeeding week, like Anteus in the fable, he would be found prepared to sustain a new contest, not, however, without having changed ground, though very slightly and skillfully between the successive assaults.

In order to assume that Ampère considered this contest an ostentatious tourney without consequences, it would be necessary to admit, contrary to all reason and probability, that voluntarily closing his eyes, he did not perceive that even blunted weapons in Cuvier's hands could inflict painful wounds. We will hasten to announce that Ampère was fully conscious of how formidable was his adversary; and if in spite of this, he continued his course, it was to fulfill what he considered a conscientious duty. In July, 1824, our associate sent to the press, but without giving his name to the publication, a theory of the organization of articulated animals. In this work, after making himself master of a single type, he followed it up amidst a thousand disguises, through the multitude of species of which the animal kingdom is composed. He sought, for example, how the fragile butterfly could be traced to the clumsy toad, the toad to the colossal whale. The criticisms of Cuvier were then addressd as well to Ampère as to the philosophers of nature or Geoffroy Saint Hilaire; and our friend decided to sacrifice all personal feelings to the interests of science and surrender the privileges of anonymity. He fullfilled this obligation without bitterness, but with firmness; he utterly disregarded the many annoyances incident to the position forced upon him by circumstances, and allowed nothing to turn him from his purpose, not even what Frenchmen dread the most, ridicule.

I still remember a dialogue that took place on one occasion, in my presence, between M. Ampère and an academician, who was the declared adversary of the unity of structure, and whose witty sallies were not only dreaded by his antagonists but often by his friends also. I will relate the beginning:

"Well, M. Ampère, do you hold, from an anatomical point of view, that Master Crow perched on a tree, did not differ from the crafty, cunning animal who carried off his cheese; and do you believe that

'The heron with the long beak set upon the long neck,'

is but a simple modification of the gossip carp he so foolishly disdained to eat for his dinner? And again, do you think the fabler was guilty of a heresy in natural history when he said:

'A rat to prove he was no elephant,
Came out of his cage in less than an instant?'"

"Yes, sir; yes," said Ampère, "I admit as facts all you have just enumerated as impossibilities. Further details on the subject would be superfluous. After the most conscientious study, I shall remain firm to a principle, apparently singular, but which time will establish; to the principle that man is formed after a model found in all the animal creation, without one single exception."

"Wonderful, M. Ampère, your theory has one rare and incontestable merit; it is clear and categorical. Je vous attends à l'escargot," (I shall wait to see you a modified snail.)

Ampère entered, for a few moments very good naturedly into the gaiety provoked in all present by this sally; but he soon began to treat seriously the laughable question just proposed to him; his manner of handling it showed the most profound research, and the most comprehensive knowledge of anatomy and natural history, and where the first step seemed to lead to absurdities, he pointed out resemblances and analogies so ingenious that we were surprised to find ourselves not regretting that the term of comparison offered to Ampère had been selected so far down in the scale of animal life.

ESSAY ON THE CLASSIFICATION OF THE SCIENCES.

The literary life of Ampère began by the study of the Encyclopedia of the Eighteenth Century, and was closed by the compilation of a plan for a new encyclopedia. The most essential feature of this vast scheme was a classification of all human knowledge.

Molière formerly, through the medium of one of the characters of his immortal comedies, asked whether it were more correct to speak of the figure or the shape of a hat; which was equivalent to asking whether hats should be classed as to shapes or figures.

The abuse of classification could not possibly be described at the same time more profoundly and more ludicrously. To go back to the time of Molière, or even to the early part of the eighteenth century, you will see the great poet was not attacking a vain phantom, and you will be struck with the strangest association of ideas; you will find the classifiers yielding to the most truly absurd analyses and comparisons; for example, in the Society of Arts, created by a prince of the blood, Comte de Clermont, a society embracing the sciences, belles-lettres, and the *mechanical arts*, the historian is classed, in all seriousness, with the embroiderer, the poet with the dyer, etc., etc.

In all things abuse is not use. Let us see, then, whether Ampère paused at the use, in the work, still only partly published, which he composed at the close of his life, and entitled, *Essay on the Philosophy of the Sciences; or Analytical Exposition of a Natural Classification of all Human Knowledge.*

Ampère proposed to undertake the vast and celebrated problem whose solution had already been attempted by Aristotle, Plato, Bacon, Leibnitz, Locke, D'Alembert, &c.

The unsuccessful efforts of so many men of genius are a convincing proof of the difficulty of the question; do they also completely prove its utility?

Aristotle claimed that all subjects could be included in ten categories. If I should recall the number of times they have been rearranged, the reply would very reasonably be, these were the necessary and foreseen consequences of the progress of the human mind. I should then, undoubtedly, propose a still more embarrassing question, by asking, of what use have the categories been?

It has already been shown what Molière thought of them. Here is the opinion of the celebrated author of the Logic of Port Royal: "The study of the categories *cannot but be dangerous*, as it accustoms men to be satisfied with words, and to believe they know everything, when they are only acquainted with arbitrary names."

To this extravagant criticism, if it had fallen under his eyes, Ampère would have replied: That a natural classification of the sciences would be the model on which the sections of an institute claiming to represent the universality of human knowledge, should be scrupulously formed: That a natural classification of the sciences would indicate the proper omissions in the subjects of a well-arranged methodical encyclopedia. That a natural classification would control a rational distribution of the books in large libraries, a matter of so much importance that Liebnitz devoted to it much thought and labor: That a natural classification of the sciences would create a desirable revolution in the art of teaching.

All this is just and true. But, unfortunately, the principles which *a priori* seemed to lead to natural classifications, have assimilated, grouped, and united the most incongruous subjects.

If you take the encyclopedical tree of Bacon and D'Alembert, which is founded on the hypothesis, against which no objections have ever been raised, that the human mind can be reduced to three faculties—memory, reason, and imagination,—you will be led in the large division of knowledge depending on memory to classify the history of minerals and vegetables with civil history; and in sciences belonging to the domain of reason metaphysics will be associated with astronomy, ethics, and chemistry.

Follow Locke, or rather Plato, and theology and optics will be found side by side. Divide, as the schools of Rome do now, all knowledge into three kingdoms, the sciences of *authority*, of *reason*, and of *observation*, and anomalies almost laughable will arise at every step.

These serious defects are not found in the classifications of Ampère. All analogous subjects are classed together; all that differ are separated. The author does not create at the will of his imagination pretended fundamental faculties for the basis of a system without solidity. His two chief points, his two *kingdoms*, are the study of the world—*cosmology;* and the study of the mind—*ontology.*

The cosmological sciences are divided, in their turn, into two sub-kingdoms, namely, the sciences which treat of inanimate objects; and those which consider only animate objects. The first sub-kingdom of the cosmological sciences is divided again into two branches—the mathematical and physical sciences. By always following out this division by twos, Ampère succeeded in forming a table in which the whole range of sciences and arts is found divided—

Into two kingdoms;
Into four sub-kingdoms;
Into eight branches;
Into sixteen sub-branches;
Into thirty-two sciences of the first order;
Into sixty-four of the second order;
Into one hundred and twenty-eight of the third order.

This is what it would be necessary to study in order to be perfectly familiar with the whole range of human knowledge.

Ought not this large number to be at the same time a subject of discouragement to individuals taken separately, and a just cause of pride to the human race? Neither one nor the other. Ampère only succeeded in finding one hundred and twenty-eight distinct sciences in the accumulated labors of forty centuries by dividing and separating what had until then been united; by changing into distinct sciences the simple divisions of the complete sciences, and by applying to them names which might well be objected to, such as *canolbology cybernitics*, *terpnognosy*, *technesthetics*, etc., etc.

It now remains to examine whether the new divisions are not too numerous; whether they would add to clearness—a quality to be sought at any price—and whether they would introduce any facilities into the art of teaching. There is scarcely a professor who does not understand now that the most elementary course of astronomy should first present to the student a description of the apparent motions of the heavenly bodies; that, on a second division, it is necessary to leave the apparent for the real; and that a third division, finally, should be devoted to the investigation and study of the physical causes of these movements. Here are three parts of one and the same whole.. I do not see, I must confess, what would be gained by making, of the first section of the first course of the subject or treatise, a distinct science, *uranography*, and by dividing the second subject into two other sciences *heliostatics* and *astronomy*.

Our illustrious associate banished from the course of general physics the comparative study of the modifications experienced by phenomena in different places and at different times. If this referred to profounder study the thesis could be sustained. But on a contrary supposition, it would be difficult to conceive how, after having announced that to-day, at Paris, the north point of the magnetic needle declined 22° from the north to the west, the professor could stop suddenly and leave to his colleague, the professor of physical geography, the office of declaring, the year after, perhaps, that at Paris, before 1666, the observers found no declination; that it is not the same at all places, and that at each place, considered apart, it exhibits a diurnal oscillation around its mean position.

Ampère found the union of the materia-medica and therapeutics in the medical course inadmissible. It is very true that a knowledge of the properties of medicine is quite different from knowing how to apply them; but when you consider that the properties in question would be but little studied but for the purpose of relieving human suffering; that their union under both points of view, abstract and practical, sustains the interest and saves time, you return to what at first seemed defective. "Life is short, and art is long." These memorable words of Hippocrates, let me add, whose truth has not been impaired by the materia-medica or therapeutics, unitedly or separately, deserve to be remembered in the distribution of the studies of youth.

Ampère thought he had succeeded in avoiding entirely all repetitions; he flattered himself that henceforth each science could be studied without any trace of syllogistic circles; that, while engaged in one study, it would never be necessary to refer to the science coming after on the synoptical table.

An illustrious metaphysician did not believe this methodical course possible unless in the science of abstract mathematics. Readers, he said, must trust; they must be willing to give credit for a time, if they wish to be satisfied; for geometers alone always pay cash.

Could Ampère always pay cash, as Malebranche expresses it, even in applied mathematics? If time permitted I could easily prove, I believe, that on this point our illustrious colleague deceived himself. In his table I see, for example, astronomy before physics; and, consequently, before optics. How, then, in the first lessons of uranography and the first study of the diurnal movements of the heavens, could the professor explain the use of the telescopes, of the lines placed in the common focus between the object and eye glasses? What could he say, without asking for credit of the atmospheric refractions which so perceptibly deform the circular diurnal orbits of the stars? All astronomers would agree with me that it is very unnatural that heliostatics, or the demonstration of the Copernican system, should precede the exposition of the laws of Kepler, considered as simple results of observation.

I could multiply these remarks, but they would not prevent Ampère's classification from being very superior to all those preceding it; it would require but a few suppressions and some rearrangement of points of slight importance to make it as perfect as would be compatible with the nature of the subject. It can be unhesitatingly affirmed that its various parts bear the indelible stamp of an erudition as remarkable for its extent as its profoundness.

Ampère had not only essayed the vast problem of a general classification of the sciences, but had also been engaged in introducing classifications into the physical and natural sciences separately.

The chemical classifications proposed by the learned academician could even now be published with profit. They would prove—and how strange the fact—that, during one of the last revolutions in the science, Ampère, the geometer Ampère, was always in the right, even when his opinions were opposed to those of nearly all the chemists of the world.

THE INFLUENCE EXERCISED BY A PRIVATE EDUCATION ON AMPÈRE'S MIND AND MANNERS.

Ampère, enjoying the wide reputation we have indicated, suggests in himself too striking a comparison between the advantages of a private education and one acquired in the tumult of public schools not to excite eager discussion. I only refer to this discussion, however, to deny its utility. At the time of his departure from the mountains of Poleymeux, our future associate possessed an immense amount of information, an extraordinary memory, a strong intellect, and a rare aptitude in mastering all subjects; but who would dare affirm that these qualities would not have been as well developed at a public school? An isolated fact could lead to no positive conclusion on so nice a point.

The adversaries of private education remembered that Ampère contracted in his secluded life habits which they tax with singularity. Amongst others is cited the impossibility he found in giving a clear explanation, when professor, of subjects with which he was perfectly familiar; without calling, as it were, to his aid peculiar movements of the body. This is undeniably true. There was always, intellectually speaking, a great difference between Ampère in repose and Ampère in action. I, especially, have always sincerely regretted that the illustrious savant, in his riper years, should have felt his eminent powers and all enthusiasm decline as soon as seated at his desk, without having, however, the temerity to ascribe it to the solitude in which his youth had been passed.

What is known, in fact, of the mental struggle accompanying the birth and development of an idea? Like the first uncertain glimmerings of a star, an idea begins its dawn on the very verge of the intellectual horizon, at first so small and faint that its unsteady, wavering light seems to reach us through an almost impenetrable mist. It increases in size, until sufficiently developed to display a delicate outline; and finally, its contour clearly defined, it stands sharply out from all around—from all that is not itself. At this last stage language seizes it, clothes and stamps it with the definite, the impressive form which will engrave it indelibly upon the memory of future generations.

The causes accelerating or retarding the birth of a thought, and its various transformations, are numerous and evanescent; and there is, moreover, neither regularity nor consistency in their mode of action. Paësiello composed wrapped up in his bed-covers. Cimerosa, on the contrary, received the inspirations that gave to the world the beautiful themes with which his operas abound in the midst of the mirth and bustle of a crowd. The historian Mezérai wrote, even at mid-day in the month of July, by the light of wax candles. Rousseau, on the other hand, gave himself up to his most profound meditations in the full light of the sun, while engaged in herborizing.

If Ampère were only inspired while standing and in motion, Descartes required to be lying down immovable, and Cujas studied satisfactorily only when stretched at full length on his face on the floor. We have all, in our youth, had occasion to smile at the sight of lazy school-boys gazing fixedly at the ceiling of the school-room, as if looking for the lesson they no longer remembered. This was the position in which Milton, his head thrown far back, always composed.

These facts seem singular; but what will you say of Guido Reni, who was incapable of inspiration unless magnificently dressed; of the musician Haydn, who declared himself utterly unable to compose his grand choruses without having on his finger the costly ring given him by Frederick II; of the poet Mathurin, who would stick a wafer on his forehead between his eye-brows, as much to excite his imagination as a signal to his servants not to interrupt him by questions.

The eyes, it has been said, are the windows of the soul. I am convinced that it would be a mistake to generalize this remark too much by extending it to gesticulations, or, if you please, to nervous action. The arms of Napoleon's chair were not hacked by a penknife in moments of anger or deep preoccupation only; joy and mirth also gave employment to his instrument of destruction. If the questors of our legislative assemblies did not place discretion in the front rank of the good qualities which distinguish them, they could tell us that some members do not less actively destroy the mahogany of their desks on the days of stormy debate than during the monotonous and drowsy operation of the call and recall. Does any one, while reading Glover's ballad entitled the *Shade of Admiral Hosier*, divine for a moment that the poet composed it while unconsciously destroying with his cane a bed of tulips, the especial delight of his friend, Lady Temple.

Uncomfortable and painful attitudes, so necessary to some, are not the only conditions indispensable to the development of the higher intellectual faculties. Addison mentions a lawyer who could never plead without passing the thumb of his left hand through a loop of twine, which he would tighten to spur the thought or expression. One of our most eloquent prose writers, who spoke as well as he wrote, was only able to do so, however, when his right leg was twisted around the left, like the serpent of Troy around the arms of the Laocoön. Let us remember all these facts. Their very singularity should induce us to do so. But let us be careful not to draw from them any premature conclusions against any particular mode of education; for amongst the distinguished personages whose names I have just cited there are no two who in their childhood were placed in exactly similar circumstances.

If necessary to enter more into detail, I should be less reserved about other habits of our associate which have more or less influenced his career. Had Ampère been sent to school in his childhood to the humblest village school, his disposition and habits would possibly have been somewhat modified. He would have learned that scissors were not intended for making pens; that writing in large characters was not the ultimate object of calligraphy. He would not have received from a foreign scientist, full of wit and waggery, after he became a member of the academy, an invitation to dinner written in the first letter of his signature. He would have known that to write a running hand rapidly and easily, a movement of the fingers, and not the arm, is required—a knowledge which would have saved him, during his whole life, much bodily exertion and intolerable annoyance. Ampère's school-fellows, much less forbearing than father or mother, would have roughly checked his incessant restlessness. He would have learned to control those paroxysms of rage which, later in life, rendered him so unhappy—called by his friends lamb-like wrath; and which to excite was rather a subject of congratulation, so spontaneous, candid, and unreserved was his repentance. He would have known how to confine himself to regular work. The necessity of performing his tasks at fixed hours would have taught him, as an author very clever in such matters said, to make his thoughts flow rapidly from the nib of his pen, and not to drown them afterwards in an ink-stand. Borrowing the beautiful image of Cleanthe, preserved by Seneca, Ampere's thoughts, once repressed, would resemble the voice, which, confined to the narrow channel of a trumpet, bursts forth at length the more clear and the more powerful. Composition would then have been of secondary importance to him, and he could have exclaimed triumphantly with Racine, "My work is finished; nothing now remains but to write it out." The success of this mode of investigation would have induced him to give up handling a thousand different subjects at once and yielding to the nervous excitement provoked by it. If he had considered the time lost in useless discussions, he would not now sadly exclaim with the poet cited not long since—

Je ne fais pas le bien que j'aime,
Et je fais le mal que je hais.

("I do not do the good I love, but the evil that I hate.")

Here I must stop; for instead of maintaining an even balance between the two contrary systems, as I had intended, I find myself almost pleading in favor of public education.

AMPÈRE AN ADEPT IN ANIMAL MAGNETISM.

Ampère often lent the aid of his imposing authority to the adepts of animal magnetism. His imperfect vision, his want of bodily dexterity, and his great credulity, rendered him a fitting subject for the tricks and legerdemains which ought to have induced him to consider magnetism a branch of the art of jugglery. At certain reunions, where the love of the marvelous, a desire to fathom the mysteries of animal organization, and especially the hope of discovering some new means of alleviating human suffering, brought many estimable people together, Ampère was often fascinated by legerdemains only suitable for the amusement of children, such as the sudden increase of little balls, multiplied almost infinitely, and passing successively into different boxes, at the will of one of those individuals now called prestidigitators. It was in this way, doubtless, that Ampère had been led to admit that, under certain conditions of nervous excitement, a man might be able to see even at great distances without the aid of his eyes; that he might, with his knee, see stars; follow the movements of actors on a stage with his back turned, and read a note with his elbow. Is it not possible that we, who even now have no faith in such marvels; we, who formerly opposed the convictions of our friend with all kinds of arguments, even resorting to raillery, might have carried this opposition too far on other points of animal magnetism? Is an extravagant skepticism more philosophical than an unlimited credulity? Have we any right, for example, to sweepingly affirm that no man ever has or ever will be able to read, with his eyes, in the profound darkness which reigns under a depth of twenty-nine meters of earth and rocks—I mean at the bottom of the vaults of the Paris observatory? Has it been well established that opaque bodies—that is, those impermeable to light—allow nothing to pass through them which could supply and produce vision? Do systematical ideas authorize us to disdain any reference to experiment, the only competent judge in such matters? I present all these doubts as a kind of reparation and expiation offered to the *manes* of Ampère.

Pardon this digression, gentlemen, rendered necessary by circumstances. Your indulgence will be the more precious to me for having possibly—nay, I will say more, probably—displeased both the advocates and antagonists of magnetism. The latter will blame the extent of my concessions; the former, on the contrary, find me too skeptical. But, such reproaches would not be very alarming; for has magnetism, unless in some few isolated points, any real foundation? All that its advocates can desire, all they can rightfully claim at present, are unprejudiced judges, who will refuse neither to see nor to hear.

Is it necessary, on the other hand, to side with those who, fanatically devoted to the experimental method, proceed exclusively by means of direct corollaries, and who regard an idea unworthy of being followed up which does not flow logically from a previous idea? I will also remark that to deny, a *priori*, belongs to theory; that negative theories are even more to be condemned, as they provoke no trial, no attempt, and therefore reduce the mind to a state of quietude and somnolence from which science would have much to suffer.

I cannot, besides, admit that there would be less pride in saying, not only to the sea but to all nature, "*thou shalt go no farther.*"

AMPÈRE'S CHARACTER.

The traits of character which, in the course of this sketch, are found scattered here and there through the scientific analyses, would amply suffice in the eulogies of a large number of the academicians. But this would not answer in Ampère's case. From an early period a singular concourse of circumstances had initiated the public into all the details of his private life. They interested themselves almost as much in what they called his credulity, his eccentricities, his absence of mind, and his very frequent alternations of wonderful activity and profound apathy, to which he was subject, as in his brilliant discoveries. Our friend gradually became the principal actor in a multitude of fantastic adventures, creations of the imaginations of a few idle people. Calumny, always on the watch for such opportunities, began early to exercise its detestable role; and thus it is that I would not attain my end were I to neglect to give a faithful sketch of the character and habits of Ampère.

I have just spoken of calumny, but am far from wishing to apply so severe a term to those who do not share the estimate I have formed of Ampère's character. Philopœmin once "*paid the fine of his deformity*," said Plutarch. Ampère also paid the penalty of certain manners and habits which it is not my intention to extol. I freely acknowledge that, with the kindest feelings in the world, no one could help admitting a want of dignity in his too profound salutations.

We have passed over times in which a man of letters, a man of science, such as Ampère, had any reason to fear that he would be stripped of his office if not orthodox in matters of religion and a partisan of the political systems of the day. Perhaps, under such circumstances, our associate recalled too vividly his responsibilities as the father of a family; perhaps an ardent imagination painted in exaggerated colors the brutal condition to which such a deprivation would reduce him; and he thus stooped to measures, such as visits and presentations, which can be legitimately and justly condemned. The right of doing so, however, can only be conceded to those who have never been guilty of like faults, and which I refuse unhesitatingly to those functionaries, infinitely more numerous, whose only advantage over Ampère is that of having discovered the secret of diverting attention. Besides, do not believe that the judgments and opinions whose organ I shall be, and which it would give me so much pleasure to have prevail here, rest on so unsound a foundation as rumor or the chit-chat of society—but on acts misunderstood and susceptible of different interpretations. I have formed an estimate and judgment of Ampère's character from a private correspondence not destined to see the light—which, indeed, in strict accordance with the express wish of our friend, should have been destroyed. In such documents I could hope to find Ampère's thoughts free from all delusive alloy. It was while reading this precious correspondence I learned more and more to love our associate. Are there many men who would thus gain by being stripped of the mask so generally worn in public? These reflections have occupied much time, gentlemen. You will pardon me if I say it is a mistake to consider them a mere preamble; they are a direct refutation, and by way of anticipation, of the objections with which the last portion of this notice is threatened, even before being given to the public.

Like Lafontaine, between whom there was more than one point of resemblance, Ampère would remain sometimes unconscious of all around him in the midst of a crowd; and from this proceeded certain eccentricities, certain aberrations of language, of carriage, and dress, difficult to be understood by those who have never known what it is to be swayed by the tyrannical domination of an idea or of a sentiment. Abstraction offends, where it does not excite laughter. Ampère's obliviousness was of the latter kind, and yet it must have offended some, since it has been fancied, and even seriously maintained, that the many instances of which we have all been witnesses were the result of affectation. This serious charge has been too widely spread to allow me to give a kind of assent by silence. I will refer, then, boldly to the contemptible circumstances which gave rise to it.

Tell us, for example, what advantage could Ampère expect the day when, seated at the table of persons whom all his interest required him to treat with deference, he exclaimed in a fretful tone, fancying himself at home, "What a vile dinner; will my sister ever understand that, before engaging cooks, it is necessary to inquire into their skill?"

I am almost ashamed to have to stoop to such a justification; for, after all, Ampère is not the only distinguished man subject to absence of mind. Would you like to generalize the charge? I can at once cite the instance of the celebrated astronomer, who, on being asked by his house-keeper the exact number of minutes required to boil an egg, found with despair that his watch, of great value, and on which depended the accuracy of all his labors, had been in the boiling water for a whole minute, while the egg was in his hand. I can mention, too, the case of the pious Father Beccaria, who, his mind filled with an electrical experiment even while celebrating mass, shouted in his loudest tones, "*L'ésperienza è fatta*," when he should have chanted the *Dominus Vobiscum;* an obliviousness, by the way, which, being reported to the ecclesiastical authorities, resulted in the suspension of the illustrious physicist.

To transform an absent-minded man, by the system just alluded to, into a sort of mixture of the impostor and the hypocrite, would be to force us to destroy some of the clever pages of La Bruyére, and to condemn to the flames an agreeable comedy of Regnard. There is still another consequence, which creates yet more disgust: the inimitable fabler would no longer be the *worthy man*, as Moliére baptized him. While admiring his immortal works, we should be forced to deprive him of that halo of respect and esteem—in fact, almost tender attachment—with which so many successive generations have surrounded him. The cause is lost, gentlemen, when it leads to consequences so violently irritating to public feeling.

Ampère's credulity had become in a measure proverbial. It induced him to believe one after another the most extraordinary facts in the political world and the most chimerical events in the intellectual. Still this avowal can create no prejudice against the wide reputation of the celebrated academician for perspicuity. Credulity usually implies a want of intelligence. This, of course, was not the case in this instance It often arises, too, from a general sluggishness of mind, and is well described by a popular adage: "*I would rather believe than examine for myself.*"

Indifference, in order to escape the importunities and contentious it so much dreads, sometimes wears the mask of credulity. But indifference cannot be general. Though felt towards certain subjects, it admits in others a wide field for active interest. Such was the case with the grammarian to whom some one was describing the fancied symptoms of a general conflagration in Europe. He admitted all, accepted all, without a frown or a word; and was about being set down as one of the most credulous men of the age, when he broke the silence by exclaiming, "Happen what will, I have not less than three thousand verbs well conjugated in my lists."

Ampère belonged to another class, infinitely more rare, with whom credulity was the result of imagination and genius. When he heard an extraordinary statement related, his first feeling was that of surprise, undoubtedly; but his penetrating and prolific mind, discerning possibilities where ordinary minds discovered only chaos, would, without interval or rest, persevere until he connected the strange phenomena, by links more or less solid, to the principles of established science.

Should I fear being accused of misunderstanding the human heart if I add that the merit of overcoming difficulties had its influence on the tenacity of our learned associate in defending certain theories? On leaving Lyons, in 1805, Ampère had not weighed well all he was relinquishing in the associations and friends of that city. Soon after his arrival in Paris he was seized with an attack of genuine nostalgia—home-sickness—from which he never entirely recovered.

In letters of 1813 and 1820, and even of a later date, his acceptance of the situation connecting him with the Polytechnic School is described as an act of egregious folly. His favorite dreams were combinations, always impracticable, to restore him to the haunts of his childhood. His griefs of all kinds always found expression in, "O, had I never left Lyons!" This, then, gentlemen, gives the key to many circumstances in the life of our friend until now inexplicable.

Metaphysics, to which I have already referred, were constantly interfering with the works on mathematics, physics, and chemistry, on which our associate was engaged. They were suspended, but at short intervals, in 1820, 1821, and 1822, during his *electro-dynamic researches*, the results of which have already been shown.

In 1813 Ampère consulted his friends in Lyons as to a plan, (I give his own words,) "to devote himself exclusively to psychology." He fancied himself called "to lay the foundation of that science for all ages." He did not reply to a letter from Sir Humphry Davy on chemistry. "No longer having," he said, "the courage to fix his thoughts on that tedious subject."

I will say no more, gentlemen, as I would be afraid by dwelling longer on the harm done to physics by psychology, of exciting against the latter too violent an opposition.

Among the writers conspicuous in literary history for their invaluable and indefatigable zeal, we shall find some profoundly pious, some indifferent, and others skeptical. Those, on the contrary, who all their lives have been harassed by internal religious struggles, have rarely succeeded in accomplishing works of great magnitude. Ampère belonged much more than we had suspected to the last class of savants.

Madame Ampère had early begun to instil into the heart of her son the pious sentiments animating her own. A diligent study of the Bible and the fathers of the church was the unfailing expedient of the young geometer when his faith was wavering. Later in life this talisman lost somewhat of its early efficacy, a fact revealed to me by some scraps of manuscript, for during his life Ampère never allowed me to perceive the cruel doubts which from time to time disturbed his mind. In glancing over to-day his letters to the friend whom he had selected as the confidant of all his mental struggles, the reader is surprised to find that he has really before him an account of the excessive tortures experienced by the author of the *Provincials*. "If this were true, however," he wrote on the 2d of June, 1815, "miserable creature that I am. * * * Former views have not the power to make me believe; but they still have the power to strike terror into my soul. If I had only preserved them intact, I would not now be plunged into this gulf."

By comparing dates, it is evident to me that these vicissitudes of feeling were not unconnected with the political revolutions of France, or with family afflictions. How readily it can be believed that the tears filling the unhappy eyes do not alone change the appearance of the external world!

In moments of religious excitement there was no literary sacrifice Ampère would not have considered light. While at the central school of Bourg, the young professor composed a treatise on the future of chemistry. In it were some bold predictions, which at the time did not alarm his conscience. The work was scarcely published, however, when various circumstances threw Ampère into an extraordinary mystical exultation. From that moment he fancied himself in the highest degree culpable for having attempted to unveil prematurely a multitude of secrets that future ages bore and still bear in their bosom; and seeing in his work only the suggestions of *Satan*, he committed it to the flames. The illustrious academican has since deeply deplored this loss in common with all interested in the progress of science and the glory of the country. Religious doubts were not the only ones which perplexed Ampère. Doubt, whatever the object, always disturbed his mind in the same degree. "Doubt," he wrote to a Lyonnese friend, "is the greatest torment endured by man on earth." Here is, among a thousand others, a question assuredly of doubtful solution, some would say quite insoluble, which exercised the ingenuity of our friend, and permit me the expression, almost transported him with enthusiasm. The study of fossil animals shows that our globe was once the theater of several successive creations, which by gradual progression at last reached the condition of man. The earth, at first, presented no living thing, no organized matter. Then were found traces of vegetation; then invertebrated animals, worms, and mollusks; later, fishes and sea-reptiles; later still, birds; and finally mammifers.

"Do you not see," wrote Ampère to one of his friends in Lyons, "do you not see the *palæotheriums*, and the *anoplotheriums* replaced by man. I hope for my part, that after a new cataclysm, men, in their turn, will be replaced by beings more perfect, more noble and more sincerely devoted to truth. I would give the half of my life for the certainty that this transformation will take place. Would you believe it? there are people *stupid enough*, (his own words,) to ask what I would gain by that. Have I not just cause to be indignant at such a question?"

It would not surprise me that any one, at the first glance, should evince astonishment at my enumerating political events and passions amongst the causes so frequently saddening and discouraging Ampère's heart, and interfering with his scientific labors. Was not I, his friend, for thirty years, obliged to read his most private correspondence in order to discover a trace of those political griefs hidden under an apparent serenity, an outward show of gentle resignation.

The year 1815 was marked by events cruelly stamped on the life of our associate. The Emperor had returned from the island of Elba; and the clash of arms resounded throughout Europe; nations were hurrying to encounter each other on unknown battle-fields, and this terrible shock might result in the subjugation of France and the world for many long years. These thoughts threw the mind of Ampère into the wildest state of confusion, and he then had the incredible misfortune to become associated with those, and God grant I may never discover any traces of them, with whom all he most dreaded was an object of hope, in whom the most disastrous news excited transports of joy; who thought that the death of half a million of our countrymen would not weigh in the balance against the preservation of their rotten institutions.

These hideous sentiments inspired our associate with a well-founded and profound antipathy. Again, he found on the other hand, among the Parisian populace many so violent that, without waiting for provocation on the part of their antagonists, proposed putting all mercilessly to the sword.

It was at this time that Ampère wrote, (I have the letter at hand) to his friends in Lyons: "I am like a grain between two mill-stones. No words can describe the anguish I feel; I have no longer strength to sustain life here, I must, at any cost, return to you, flee from those who say to me, 'you will suffer no personal inconvenience;' as if I could think of myself in the midst of such catastrophes."

Would you not, gentlemen, have a bad opinion of a man who, under circumstances so sad, could command sufficient tranquility of mind to be able to combine formulas, invent apparatus, and make new experiments?

Ampère, from diffidence, carefully concealed the painful feelings inspired by public events. Twice, however, the measure of his grief was full to overflowing, too full to be restrained. I can cite but one instance of such despair as that experienced by our associate when informed of the fall of Prague, and later of that of Warsaw, to be found, too, among the former members of the Academy. It was that of Ruello, who entering the room with his clothes in disorder, his face pale, his features distorted, began a lecture on chemistry in these words, which I prize as highly as the most beautiful experiment: "I fear I shall fail today in clearness and method; I have scarcely strength to collect and connect two ideas; but you will pardon me when you learn the Prussian cavalry were passing and repassing over my body all night."

The news of the battle of Rosback had reached Paris the evening before.

Once surrender yourself to the influences of mind, temperament and heart in the contemplation of political events and the calculation of their importance and weight and you will find it difficult to confine yourself to those of one period, even were it as fruitful in terrible catastrophe as the close of the eighteenth and beginning of the nineteenth centuries. Biographers relate that Lamothe-Levayer died, demanding in a faint voice, "What news of the Grand Mogul?" With Ampère the Grand Mogul was the whole world, time, past, present and to come. The sufferings of the subjects of Sesostris, Xerxes, and Tamerlane touched in his heart as tender a chord as did those of the poor peasants of La Bresse, among whom his youth was passed. To use his own words, he took the same strong interest in what might take place centuries hence, as in what was passing under his own eyes. We still recognize in this the horror of the doubt not long since alluded to, but now supported by philanthropic sentiments.

"Friends," exclaimed Lord Byron, in a moment of ill-humor, "are robbers of time." A great student said before him, but with less asperity, "Those who come to see me confer an honor, those who do not come confer a favor." Such a thought, equally selfish, in either form, never sullied Ampère's heart. His study was open to all at all hours. But no one ever left, we must confess, without being asked by our associate if he understood the game of chess. If the answer were in the affirmative, he would seize the visitor, and force him to play, willingly or unwillingly for whole hours. Ampère was too unsuspicious to perceive that unskillful players, (several have themselves told me so,) knew an infallible way of winning; when fortune seemed against them, they would declare, in very positive terms, that after very mature reflection it seemed to them that chlorine was undoubtedly oxygenated muriatic acid; that the idea of explaining the properties of the magnet by means of electrical currents was truly chimerical; that sooner or later physicists would return to the system of emission and consign luminous waves to their place among the rusty old lumber of Cartesianism. Ampère had thus the double vexation of finding pretended adversaries of his favorite theories and himself check-mated.

Philosophers, even those whose whole lives have been passed in digesting codes of wisdom for all the nations of the world, frequently, in regulating their own lives, fail to steer clear of the shoals evident to the eyes of the most casual observers. Ampère, for example, never seemed to understand how much both his health and science would suffer from the isolation to which he had condemned himself. He fancied he was yielding to peremptory medical prescriptions, or to the urgent entreaties of friendship, and he really believed he was resting his mind, when, during the day, he passed several hours either in profound darkness, or without book, pen, or pencil in hand. Such a delusion could not deceive us; and it was not strange, therefore, that we desired to lure our friend, for real distraction, to the Comedie-Française; we were anxious that he, who, in his youth had composed tragedies, should participate in the pure and elevated pleasure excited by the master-pieces of Corneille, Racine, Moliere, and at a time, too, when these immortal poets had for interpreters such artists as Talma, Fleury, and Mademoiselle Mars. Fearing our friend might be restrained by the powerful influence of his religious scruples, we concluded to relate to him the instance of the lady at the court of Louis XIV who, in consulting her confessor as to whether she committed a sin in going to the theater, received this reply: "*Madame, it is for you to tell me.*" These admirable words could not fail to make an impression on so quick and discriminating a mind as Ampère's. For a moment we thought our cause gained; in fact, his mind and heart were convinced; but how could we insist when we saw he hesitated from the very praiseworthy fear of wounding the feelings of those whose opinions he regarded?

I shall have displayed a great want of skill, gentlemen, if in the character of Ampère, presented to you under so many different phases, I have not seemed to offer, at least within certain bounds, a very natural explanation of the despondency to which our friend so often abandoned himself, and given the principal causes of the distaste so frequently inspired by studies that a slight perseverence would have crowned with a brilliant success. A careful glance over the later years of Ampère's life will detect numberless instances of this despondency and distaste.

He who in his youth had devoured books of every description, even the twenty volumes in folio of the encyclopedia, after reaching a certain age seemed no longer to have the energy to read. With only a few exceptions the books of his library remained uncut. Here and there a few leaves were found jagged at the edges like a saw, certain proof of their having been separated by a misapplied finger. An author, even amongst the most celebrated, would have vainly sought for more numerous and more manifest traces of the interest and curiosity of our friend. With the single exception of the plan for a natural classification of all human knowledge, to everything in the scientific and literary world he had become so indifferent that, as a proof, there now is in the hands of geometers, and the students of our large schools, a *treatise on the differential and integral calculus*, without the name of the author, title, or table of contents; the publisher, after many ineffectual attempts, was forced to conclude that Ampère would never furnish the few lines necessary to give the new book the form of all books since the time of Gutenberg.

Do not exclaim, gentlemen, at the singularity of this fact. I have, according to my judgment, something still more extraordinary to relate.

Fresnel, that illustrious physicist, who carried the experimental art to its utmost limits; who, in the discussions of the most complex phenomena, succeeded, by the force of genius, in dispensing with those powerful but almost inaccessible aids found now in transcendental analysis—Fresnel, by his death, left in the scientific world a great void, which, in one respect at least, Ampère could have filled. Friends urged it; they painted in brilliant colors the glorious future of fame and usefulness which would be added to a reputation already European; but it was all in vain. Ampère was deterred by an incredible obstacle; he could not accept the position offered, because, he said, it would place him under an obligation to read two essays on the theory of waves, with which science had just been enriched by M. Poisson. (The two essays were written with the elegant precision which distinguishes all the works of that illustrious geometer.) Ampère's excuse will astonish every one; but he gave it in so feeling a tone that to show displeasure would have been an act of barbarity. If great and small things may be compared, they would remind me of the reply of the young and able-bodied workman to this question of Marivaux, "Why do you not work?" "Ah, sir, if you only knew how lazy I am!"

The large share I have just ascribed to influence of character must not divert our attention from a cause not less powerful, which has itself greatly contributed to diminish Ampère's works. If it is true that the discoveries whose analysis I have just given, in spite of all they present of the vast, the profound, and the ingenious, form but an inconsiderable part of those which might have been the fruits of the powerful intellect of our associate, the institutions responsible (solidaires) for so sad a result merit the reprobation of every friend of science. I will follow, gentlemen, by devoting a few words to the development of this idea, the sensible advice of the author of the Essay on Eulogies: "In describing great men, whether you emulate the gravity of Plutarch or the pungent good sense of Fontenelle, do not forget that your aim is to be useful."

Among the contemporaneous savants whose wonderful talents have been misapplied, no name is more prominent than that of Ampère.

A statesman, celebrated for his witticisms, said of one of his political adversaries: "His vocation is not to be minister of foreign affairs." And we, in our turn, might say of Ampère: "His vocation was not to be a professor."

And yet he was forced to devote the best portion of his life to a professorship, and to supply the deficiencies of his patrimony by paid lectures.

A severe wound received in his arm in childhood had no little share in impairing his manual dexterity. The first place, nevertheless, that is given him is that of professor of physics, chemistry, and astronomy, at the central school in the department of Ain. The professor of physics invariably fails in his experiments; the chemist breaks his apparatus, and the astronomer can never succeed in bringing two stars within the field of the telescope of the sextant or circle of reflection. Are such the real difficulties encountered by the modern type of the functionary called the administrator? He derives from his office the right to appoint; a vacancy occurs; he fills it, and there is the end of it.

Ampère left Bourg to fill the chair of mathematics in Lyons, and afterwards the office of master of analysis in the Polytechnic School at Paris. In this new position he was not obliged to handle retorts, electrical machines, and telescopes; more complete success might now be expected; but he who undertakes the instruction of frolicsome, restless, and petulant youth, quick to seize the slightest occasion of ridicule to minister to their amusement, will find knowledge and genius not all that is necessary for the task. To avoid giving occasion to their mischievous acuteness, it is necessary to study, by living for a long time in their midst, their tastes, their manners, their tempers, and their peculiarities. The man whose character has been moulded by himself, who has not been trained in public schools, lacks one of the elements of success. If your bow is too profound, instead of receiving acknowledgements for the deference, you excite peals of laughter. Eccentricities, ignorance of the world, and what is called in our artificial society a want of style, did not interfere with Ampère's right to rank first among the savants for perspicuity and ingenuity; but we must acknowledge his lectures suffered in consequence. But the superior powers of a man of genius should have easily commanded a more judicious and useful position; and science itself, with its exquisite sensibilities, must regret that one of the noblest and most glorious of its representatives should have been exposed to the jests of giddy youths and idle minds.

In the seventeenth chapter of his second book of his celebrated essays, Montaigne makes this confession: "I can neither calculate in my head nor on paper; the greater part of our coins are unknown to me; nor do I know one grain from an other, either in the field or in the barn, unless the difference is very apparent; nor can I distinguish cabbage from lettuce in my garden; and I understand still less of traffic; and my knowledge of merchandise is more limited still."

Ampère, who was a very skillful botanist, would never have confounded cabbage with lettuce, but he was as little skilled as the philosopher of Pingueux in traffic and merchandise, which is shown by the astonishment he expressed when wishing to initiate himself somewhat into the details of his little household; he saw fifty francs for parsley in the expense of a month, and six hundred francs for the whole year.

This, then, nevertheless, is the man who, for more than a quarter of a century, received each year as inspector-general of the university the mission of controlling the expenses of our principal colleges; and think not he was better qualified to examine the professors and scholars, for, once excited, his ardent imagination would straightway overleap the boundaries of classic theories. A word in jest or seriousness would often hurry him into unknown paths, which he would explore with the most surprising clearness, utterly unconscious of his surroundings. It was in this way that year after year the theory of Avignon, the demonstration of Grenoble, the proposition of Marseilles, and the theorem of Montpellier, enriched his public lectures delivered at the polytechnic school and college of France; but this habit of our friend of distinguishing each of his conceptions by the name of the place where it originated, makes us fear that he did not give at Avignon, Grenoble, Marseilles, and Montpellier that individual attention that duty required of the examiner.

If Ampère little suited the office of inspector-general of the university I can assert the office as little suited him, for his domestic responsibilities, a beneficence often exceeding the limits of prudence, at times, too, when his friends were anxiously calculating *how much his wants exceeded his means*, the extravagant habit of altering unnecessarily the proofs of the printing-office, his endless desire for the construction of new apparatus for electro-magnetism, prevented Ampère from resigning the principal source of a modest income. So far from this, every year when the offices were distributed in the bureaus of the university, did we see our friend submit with resignation to the business of a solicitor to obtain a position which might injure his health and could not add more than a hundred francs to his domestic economy, and waste in painful, humiliating, and frequently fruitless efforts his most precious time.

Finally, he departs, and for three or four months the author of the subtle theories of electro-dynamics goes from department to department, from city to city, from college to college, contending with a parcel of wretched children. Whole days are passed hearing them decline, conjugate, and explain passages from *de viris* and the metamorphoses, or in detaining them before the so much dreaded black-board, where they stammer over the certainly very harmless, but very prosaic, rules of multiplication, division, and the extract of roots. The hour of return has also its tribulations of a different nature, but not the less poignant. The portfolios of the universities have hastily stowed away in their recesses minute lists of the barbarisms, solecisms, and errors in calculation, which the inspector-general must examine. Their gaping jaws also demand the accounts, giving the expenditures for the bedding, furniture, and provisions of thirty boarding-schools. It is in vain our friend, who has scarcely the power to reduce his own favorite works to writing, is asked for such accounts. In a letter, after enumerating the numerous and very just causes of annoyance by which he was besieged, he gave the finishing touches to this sad picture in these words: "The severest and most painful of duties is to be seated, pen in hand, immoveable before a desk." Ampère would then have to submit to the demands of the clerk, the head of the bureau, the chief of the division, and the minister, all leagued against him; and during these daily struggles, prolonged until the time for new inspections, he expended more time, more ingenuity and thought, than were required to produce a chapter of his theories of electro-magnetism.

So miserable a prostitution of the highest intellectual faculties can have no supporters within these walls nor anywhere else; but some one asks, Where is the remedy? The remedy would not be difficult to find. I would suggest that the colossal budget should not forget that France is covetous of all kinds of glory. I would suggest that it should guarantee an independent support to the limited number of men whose productions, discoveries, and labors command the admiration and are the characteristic features of all ages. I would suggest that these intellectual powers as soon as discovered should be placed under the tutelary protection of the whole country; that it should watch over their full and complete development; that it should not permit them to be wasted on common-place subjects. Any objections to which this plan could give rise must be more specious than solid. I had summed them up and refuted them, but a want of time obliges me to defer this portion of my work to another sitting. I intend to make it the subject of a special proposition on which I shall ask the opinion of the public before submitting it to the decision of a legislative vote. There is, however, one point about which, from this time, there could be no difference of opinion, for every one will acknowledge that, under the liberal regime I have just sketched, Ampère would have been one of the first of savants to feel the effects of his country's munificence. Free, then, from all care and anxiety, released from a multitude of laborious occupations, niggardly details and petty services, our friend would have been able to carry out with ardor, enthusiasm, and perseverance the thousands of ingenious ideas with which his mighty brain was daily teeming. I remarked not long since that the discoveries and works which he has left behind him, would occupy a distinguished place in the history of science, and be honored by posterity, and I added, too, without the fear of contradiction, that they were but a small portion of what there was every reason to expect from one of the most subtle and profound minds ever created from the so rare union of the spirit of detail with the powers of generalization. This idea did not originate with me. I discovered it sometimes unveiled, sometimes veiled, in every page of Ampère's correspondence with the friends of his youth. Each day our associate, unfortunately, weighed in the balance what he had done and what he should have done, and each day the results of this examination increased his intense sadness.

You now know the secret of what embittered his whole life; of his desire to have inscribed on his tomb the brief but most expressive epitaph, also selected by a celebrated Swedish minister—

Happy at last! (Tandem felix.)

DEATH OF AMPÈRE.

Ampère left Paris in a suffering condition, August 17, 1836. His friends, notwithstanding, were full of hope and confidence, inspired by the thought that a southern climate had once before restored him to health. But M. Bredin, who had joined him at Saint-Etienne, did not share this delusion. The learned superintendent of the veterinary school of Lyons discovered in Ampere's appearance unmistakable symptoms of decay; his whole face seemed changed, even the bony outline of the profile. All that remained unchanged about him was, and this was exerting the most fatal influence on his already shattered condition, the enthusiastic and absorbing interest he evinced in everything, north, south, east, or west, that could possibly ameliorate the present condition of the human race. The racking cough which was weakening our friend by slow degrees, his painfully changed voice, his increasing feebleness, all demanded silence and absolute rest, even those least interested in him would hesitate to make him utter ten words; yet when M. Bredin declined to enter into a minute and difficult decision on the proposed changes in the second volume of the *Essay on the Philosophy and Classification of the Sciences*, Ampère became most violently excited. "My health, my health!" he exclaimed. "To talk of my health! There should be no questions between us but those of eternal truth." These exclamations were succeeded by a profound development of the delicate subtle links, imperceptible to the generality of men which unite the different sciences. Then passing beyond the conditions at last conceded by M. Bredin, Ampère, kindling with enthusiasm, summoned to his presence, for more than hour, all who, in ancient or modern times, have influenced, for good or for evil, the lives of their fellow-beings. This violent effort exhausted him, and increased his illness during the remainder of the journey. On reaching Marseilles, the city of his affections, which once before had restored him to life, and which had overwhelmed his son with so many warm-hearted kindnesses, he seemed in an almost hopeless condition. The tender and respectful attentions of all the functionaries of the college and those of a skillful physician produced a slight improvement. His want of great age, too, seemed a source of hope, for no one recollected that Ampère might have said, with the Dutch artist Van Orbeeck, "Count double, gentlemen, count double, for I have lived day and night!"

Our associate did not share the hopes of his friends. When leaving Paris he knew himself near death, proof of which I have found in a letter recently sent to me, in his answer to the urgent exhortations of the chaplain of the college at Marseilles. "Thanks, M. Abbé, thanks; before starting on my journey I performed all my religious duties." Ampère's resignation in his last moments astonished all who knew his excitable disposition, his lively imagination and warm heart. No one ever expected to find him display the calmness of that ancient philosopher, who, on the bed of death, requested to have all disturbing influences removed, in order, he said, to be able the better to observe what would take place at the exact moment of the separation of soul and body. A few moments before our associate lost entire consciousness, M. Deschape, provisor of the college of Marseilles, beginning to read in a low voice the *Imitation*, Ampère remarked that he "knew the book by heart." These were, I believe, his last words. In addition to the fatal chronic affection of the lungs, he was now seized with a high fever; and on the 10th of June, 1836, at five o'clock in the morning, our illustrious associate, sinking under the accumulated bodily and mental sufferings of sixty years, as Buffon so beautifully expresses it, "died before he had finished living."

The same day the wires of Marseilles transmitted the sad news to Paris, where it excited, as you remember, the most profound and universal grief. And let no one think this swift ærial messenger dropped, in this instance, its official role to intrude itself into the domain of private life; for Ampère's death was a public calamity.

[The following sketch, which was originally published in Blackwood's Magazine, furnishes an illustration of some traits of the character of Ampère as presented by Arago:]

Ampère, the friend of Davy, and whilome one of the great natural philosophers of France, is selected for this sketch, not from the space he at present occupies in science, but for *la petite comédie que voici*,* and the amiable old age he exhibits. You see a venerable *octégenaire*† of small stature, clad in a coat of grotesque cut, on which the marks of climactercial decay are as visible as upon the excellent old man who has borne it for a quarter of a century. He has parted with his teeth, his memory, and his elasticity of step, but he retains his *bonhommie*, his delightful mannerism, and ever and anon exhibits some flickerings of that enthusiasm in the cause of science with which he began life and without which nothing is to be done. I dare not, however, meddle with the splendid fragments of that genius which so often startles you into the conviction that a great man is addressing you. I have been present at several amusing little scenes enacted between himself and his pupils; and one or two are so illustrative of amusing simplicity and a not-to-be-superannuated good-nature, that I shall venture to try their effect second-hand. On the very first day I went to hear him, (it was an introductory lecture,) he had so filled the *slate* with first and secondary branches of the goodly tree of science as to leave no room for more boughs, unless by topping the head and abridging the undue growth of the original shoots. Space was wanted, and the remedy should have been at hand; but, lo! the sponge had disappeared, and could nowhere be found, though the class showed much *empressement* in seeking it. At last, with a look most comically solemn, the old gentleman drew out his cotton representative for a *foulard** and looking first at the slate and then at the *mouchoir*,† plainly could not make up his mind to sully its gaudy colors by exacting from it the office of the sponge. But while necessity and reluctance were contending for the mastery on his features, the sponge was picked up by one of the students and eagerly presented to M. Ampère, whose delight and manner of expressing it were irresistibly comic. Seizing it between both his hands, as if to be sure that it was not the shadow of the *veritable* detergent, but the very substance that he held, he hastened to the door, and putting his head out, called to his assistant, *à la Molière*, in the happiest and most unconscious imitation of the *de Pourceangnac* accent "*Je l'ai trouvé; c'est à dire, on l'a trouvé—il n'entend pas.* [Aside:] *Monsieur! Ecoutez donc!*" Then at the highest pitch of his voice, "*Monsieur! ne vous donnez pas la peine de la chercher; je l'ai ici; on vient de la ramasser!*" "I have found it, that is to say, it is found. He doesn't hear me, (aside.) Monsieur! I say, Monsieur, don't trouble yourself about it; I have got it here; they've just picked it up!" Then, quite regardless, and apparently unconscious, of what the French journalists call "*une vive explosion d'hilarité*"‡ from the class, he resumed as if nothing had occurred. He had been lecturing on the polarization of light and heat, and had assumed a square ruler and a pasteboard almanac to represent a cylindrical ray and a transparent medium of transmission, when gradually warming with his subject, he began (as one is apt to do in lecturing) to describe parabolas with his ruler, one of which encountered the tumbler, (which is here *d'usage*,)§ and broke the pieces of glass into his *eau sucrée*.|| (Without *eau sucrée* nobody could get on with a lecture at the College de France or the Sorbonne, though law and physic lecture with unlubricated *fauces*.) Out of this half-demolished glass, he was presently preparing to drink, when half a dozen voices at once called out, "*Monsieur Ampère, eh, Monsieur Ampère, q'u allez-vous donc faire?*" "Monsieur Ampère, oh, Monsieur Ampère, what are you going to do?" But he, nothing heedful of these exclamations, raised the tumbler to his lips, and began to sip its now dangerous contents. In an instant one of the

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*The little farce which follows.

†An eighty year old.

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*A real bandana.

†Handkerchief.

‡A loud burst of merriment.

§ Customary.

|| Sugar and water.

foremost in the class springs forward and seizes the old man's hand, another wrests the tumbler from his grasp. A scene! Profound silence in the class! The venerable man looks at them ironically. "Thank you, gentlemen! Very kind of you! But you are giving yourselves unnecessary trouble! I took it for granted that my class understood the laws of gravitation. With your permission, gentlemen, I will first drink my *eau sucrée*, which I want, and will then give you a hint, which *you* appear to want." He now drank without further molestation, and then drawing in a long breath—"*Eh! comment, Messieurs, voulez vous qu'il est en du danger! Ne savez-vous donc pas que le verre est plus pesant que l'eau?*" "What, gentlemen! then you thought there was some danger! But ain't you aware that glass is heavier than water! And did you not observe how careful I was to drink the contents of the tumbler at a reasonable angle?" Then, taking up the tumbler, he continued to incline it over the table till it was nearly horizontal, and so on, till the pieces of glass fell out, and the class laughed. "*Ah! si je l'avais bu à cette angle-là!—mais j'ai été plus adroit!*" "Ah! if I had drunk at this inclination!—but I was too knowing for that." Here (for it was at the end of his lecture that this little episode occurred) a bright-eyed damsel went up and asked some question respecting the course of rays of light through certain media, but whether old Ampère referred her to his heart, as we should have done, we could not hear. She colored, however; her eyes seemed pleased with the interpretation given to her question, whatever it might have been, and they walked out together—a "January and May"—separated only by the insecure partition of the pasteboard almanac which the elder of the months still kept in his hand.

THE SCIENTIFIC LABORS OF EDWARD LARTET.*

BY DR. P. FISCHER.

The Geological Society of France has always paid due respect to the memory of the men who have taken an active part in its transactions and whose scientific reputation ought in justice to be perpetuated. M. Gervais, president of the society, has already expressed the universal regret caused among us by the death of M. Lartet, and one of his pupils may now be allowed to review the labors of the estimable man whose loss we deplore.

Edouard Amand Isidore Hippolyte Lartet was born on the 15th of April, 1801, in the department of Gers, at Saint Guirand, near Castelnau-Barbarens. He was descended from a family which had settled in the country at a very early date. He was the youngest of five brothers, with whom he was sent, for education, to the Lyceum at Auch, and he was one of the three pupils who received the medals awarded to that establishment by the first Napoleon. His predilections were for history and archæology rather than the judicial sciences, but, in deference to the wishes of his father, after leaving the college of Auch he entered the law-school of Toulouse, where he graduated in 1820. By a singular coincidence, Cuvier, then counselor of state, signed, instead of the minister of public instruction, the diploma of a youth afterward to be distinguished in the path which this eminent scientist had opened to paleontology.

In order to perfect him in the practice as well as the theory of his profession, he was now sent to Paris, in company with an elder brother. Here, while fulfilling the duties imposed upon him with that fidelity which characterized him throughout life, he found time for his favorite studies. After he had mastered the rudiments of these sciences, he continued to pursue them, and as his store of books was not large he sold those he had read in order to obtain others. When he returned to Gers he was not only prepared for the practice of the law but for the especial researches which afterward rendered his name illustrious.

M. Lartet, after completing his law education at Paris, settled in Gers. The practice of his profession was, however, confined to giving advice to the peasants, which was the more highly appreciated because gratuitous. Frequent emanations of this kind from the kindness of his heart constituted a prominent trait of his character. Impelled by gratitude his clients frequently brought him medals of Gallo-Romanic antiquity which they had found accidentally, and such fossil bones as had attracted their attention.* One of these gifts, the tooth of a mastodon, seems to have determined his true vocation, and led to one of the most important discoveries in geology, that of the contents of the marl-pit of Sansan. He soon gave himself up entirely to the study of geology and comparative anatomy. He made several underground explorations, and then, having entered into communication with some of the savans of Paris—Blainville, Arago, Flourens, Geoffroy St. Hilaire, Michelin, Desnoyers, &c., commenced the publication of his researches. From 1834 to 1870 he labored unceasingly in the development of new and interesting results; but in order to appreciate his investigations, it is, I think, necessary to group them under three principal heads, and to examine in succession the publications relating to the fauna of Sansan, to tertiary paleontology, and to the quaternary period.

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*A translation for the Smithsonian Institution of "Note sur la vie et les travaux d'Éd. Lartet, par M. le docteur Fischer, lu à la séance générale annuelle de la Société géologique de France," from "Vie et travaux d'Édouard Lartet: notices et discours publiés à l'occasion des a mort," pp. 39–55.

I.—INVESTIGATIONS RELATIVE TO THE MARL-BEDS OF SANSAN.

The existence of fossil bones at Simorre, in the department of Gers, had been noticed in 1715 by Réaumur, but no one had described this deposit or studied its fauna. M. Lartet, who resided at a short distance from Simorre, and who had discovered marl-beds much richer at Sansan, was surprised to find that important differences existed between the remains of vertebrata of these two localities. The fauna of Sansan presented a large number of new species of mammals, and was terminated by the existence of a stratum containing numerous terrestrial and fluvial molluscs. M. Lartet described the strata of Sansan in a letter addressed to Geoffroy Saint Hillaire in 1834. Encouraged by his discoveries, he undertook a series of methodical researches, which were soon to render famous the locality of Sansan as well as the name of the naturalist who explored it. In 1837 the work was sufficiently advanced to establish the general characteristics of the two fauna of Simorre and Sansan. While at Simorre the dominant species were reduced to two dinotheria, five mastodons, three rhinoceroses, one pachyderm resembling the wild boar, one small stag, and one large ruminant; at Sansan the dinotheria appeared to be wanting; the rhinoceroses were different—had four fingers upon the fore feet. Among other mammalia was observable one paleotherium resembling that of Orleans, one anoplotherium, one animal similar to the anthracotherium, several stags, one antelope, one small ruminant, one gigantic carnivore, its teeth indicating affinity with the cat and the dog, one dog, one large cat, several rodents, &c. But the two most remarkable specimens of the fauna of Sansan were undoubtedly a large edentate and a veritable monkey. The edentate seemed to M. Lartet very similar to the gigantic pangolin of Cuvier, but as its teeth were molars it could not be classed in the same family as the pangolin. As to the monkey, the lower jaw and its dentition were complete—four incisors, two canines, four false molars, six molars; in all, sixteen teeth in a continuous series—the dental formula of man and of some monkeys.

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* The peasants suppose these specimens were the creations of the devil, who imitated in the bowels of the earth the works of the Deity.

M. Lartet comprehended immediately the importance of the discovery of the monkey of Sansan, and the influence it would have upon the progress of paleontology. "We have here," said he, "a mammal of the family of monkeys, contemporaneous with the palœotherium and the anoplotherium, extinct genera long considered the most ancient inhabitants of our continents. Types of certain genera are not, then, so recent as has been generally supposed. Perhaps sooner or later further observation may teach us that this ancient system of nature, still so little known, was neither less complete nor less advanced in the organic scale than that in which we live. M. Lartet's communication produced quite a sensation in the Institute, and excited a discussion the interest of which may be appreciated when we recollect that at this time Cuvier's "Researches on Fossil Bones" formed the alpha and omega of the paleontology of vertebrates.

Cuvier, after a critical examination of the bones of men and of monkeys supposed to be contemporary with extinct species, proved that they were not authentic. He then remarks upon the tardy appearance of the monkey and man. It is astonishing, he says, that among all these mammalia, the larger number of which have living representatives in warm climates, not a bone or tooth of a monkey has been found. No trace whatever of man—all the bones of the human species hitherto discovered among the fossils were placed there accidentally. In thus associating the time of the appearance of man with that of the monkey Cuvier gave great eclat to the happy discovery of the monkey of Sansan, as it was very probable that the discovery of the fossil monkey would be followed by that of the fossil man.

The caution of Cuvier in regard to the antiquity of man has been in these latter days singularly exaggerated. Instead of blame he ought to receive praise for the precision of his researches, the most important result of which has been to compel the supporters of the antiquity of man to bring forward positive and multiplied proofs in support of their hypothesis instead of premature assertions. It would be well if some of the advocates of tertiary man had possessed a small portion of the critical acumen which was one of the most important characteristics of the mind of Cuvier.

Blainville, who prepared the report of the communication of M. Lartet, agreed with him, after the examination of the jaw, in the opinion that it had belonged to a monkey of the old world—a monkey superior in degree, and that no living species was identical with it. From the above conclusions he proceeded to the discussion of trivial and unimportant points of anatomy. He regarded paleontology merely as a description of fossil animals compared with their living representatives. The idea of a succession of living beings in order of time; of the diversity of fauna according to their geological periods; of their correlation with the temperature, the extent, and the flora of ancient continents, did not occur to his purely analytical mind. It was far otherwise with Geoffroy Saint Hilaire, who, notwithstanding his errors, his obscurity, and the affectation of his language, boldly sought to penetrate the mystery of a science still in its infancy. Geoffroy called his articles *Remarks upon the singular and important fact in natural history of the existence of a species of monkey found in the fossil state in the south of France.* "It has been asserted," he says "that the monkey of Sansan is allied to the ape of the Sunda Islands, and yet the animals thus related, the one so old, the other now existing, are separated by thousands of centuries." We would suppose that, in contemplating fossil bones, the idea of their wonderful antiquity would alone completely absorb the mind. "The discovery of the fossil jaw of the monkey by M. Lartet seems to me to be the commencement of a new era in the knowledge of the human species; of new research into the distinguishing characteristics of the various ambient media; of closer approximation to the laws which govern those grand domains of the universe, where from age to age the mutation of things is accomplished."

Certainly the successful labors of modern paleontologists in relation to the climate, the fauna, and the flora of the tertiary and quarternary periods, have realized the aspirations of Geoffroy Saint Hilaire. What progress has been made in this difficult branch in less than thirty years, and how much may be anticipated from the future of a science whose development has been so rapid! It is easy to foresee the light it will throw upon the history of the evolution of life upon our planet. But Geoffroy Saint Hilaire went still further—the new facts disclosed by paleontology he regarded as so many new arguments against the theory of the fixity of species maintained by Cuvier. "The incessant mutation of things," he writes, "is a dominant fact verified by every new geological discovery." We see by a review of these discussions how much the savans of the Institute were at that time engrossed with the problems of paleontology. Blainville shortly after read before the Institute a report upon a new set of fossils from Sansan, which were described by M. Lartet in a letter to Flourens.

M. Lartet observed a singular conformation in the stags of Sansan; the horns seemed the same at every age, and to all appearances were not dropped as those of living deer. M. Lartet proposed the name dicrocerus for this group of ruminants. Blainville approximated them to *(C. muntjak)* the genus cervulus, whose very prominent frontal prolongations are crowned by horns which are shed every year.

An accidental discovery, at this time, of a peculiarity in the dentition of the ruminants of Sansan will be more fully described elsewhere. The evolution of the second molars is quite complete before the loss of the false molars or milk-teeth, while in living animals of the same group the milk-teeth are replaced before the appearance of the last molar.

The composition of the teeth is also not the same. Cortical or cement was wanting in those of the ruminants of Sansan, although found in the teeth of the fossil ruminants of Auvergne, most of which are more recent.

These ingenious researches of M. Lartet formed the germ of a work which appeared in 1868, in which he laid still more stress upon the differences between the fossils of the same genus of successive geological periods in regard to the structure of the teeth and the size of the brain.

In 1839 M. Lartet published his first summary of the discoveries in geology and paleontology in the department of Gers, with an appendix, in which were described forty-four species of fossil vertebrates. Another article, published in 1851, under the title, "*Description of the Hill of Sansan*," was exclusively devoted to the paleontological examination of this locality, and of the other fossiliferous deposits of Gers. The author, in order to explain the richness of the fauna, and the profusion of bones found, supposes that a lake existed at Sansan in which the lacustrine molluscs lived, and into which the vertebrates were thrown after their death. He shows that great difference exists between the fossil and the living fauna of Sansan, and will not admit that the existing animals descended directly from the miocene animals reconstructed by himself. Finally, he gives a complete list of all the vertebrates he collected, with the addition of a catalogue of the terrestrial and lacustrine molluscs described by Saint Ange of Boissy, Noulet, and the Abbé Dupuy.

This list, after its publication, was modified to suit the changes in nomenclature, and then confided to M. D'Archiac, to be inserted in his report on the Paleontology of France, (1868, p. 360.) The fauna of Sansan comprises seventy-one mammals, representing thirty-nine genera, eighteen birds belonging to twelve genera, twenty-eight or thirty reptiles, a few fishes, and forty molluscs of twelve genera, the largest collection of vertebrates in our country; and very few localities in the world could show a similar accumulation of animals in as limited a space.

In 1845 M. Lartet sent a synopsis of his recent discoveries at Sansan to the Institute. "About 8,000 or 10,000 remains have been collected, among them the bones of a large fossil edentate or *Macrotherium*, and enough parts of a dinotherium to convince naturalists that this animal is not cetaceous, but rather a terrestrial quadruped. There is not a single species identical with existing forms. This special point on the earth's surface known as Sansan, has, it seems, given birth to a variety of mammals much greater than that now existing. Every degree in the animal scale has been here represented, including the monkey. A still higher type—that of man—it is true, has not been found; but because he is wanting in these ancient formations we need not conclude that he did not exist."

These ideas in regard to the fossil man were singularly in advance of the age in 1845. It almost seems as if M. Lartet had a presentiment of the important part he was to take later in the scientific discussion of the contemporariness of man and the large quaternary mammals.

Through the intervention of the professors of the museum, the ground where the excavations had been made at Sansan was purchased by the government, and M. Lartet gave to the museum his rich collection of fossil vertebrates, which may now be seen in the galleries of that establishment. In 1851 new excavations were made under the direction of MM. Laurillard, Merlieux, and A. Milne-Edwards; and in 1869 M. Lartet himself presided over some explorations, which led to the discovery of some very interesting fragments of large mammals and numerous remains of small vertebrates.

II.—INVESTIGATION IN REGARD TO TERTIARY PALEONTOLOGY.

The scientific activity of our lamented fellow-member was not confined to the study of the fossil fauna of Gers. We are indebted to him for a number of articles upon various subjects connected with paleontology.

In 1855, Constant Prévost announced to the Institute the discovery, in the osseous conglomerate of Mendon, of the tibia of a bird, of a very large size, called *Gastornis Parisiensis*. The zoological affinities of the gastornis were warmly discussed. M. Hébert considered it a palmiped, nearer a swan than a pelican; M. Lartet, although he allied it to the lamellirostral palmiped, thought that it came from a bird less essentially a swimmer; Valenciennes compared it to the albatross, and Duméril to the stork, while Richard Owen thought it resembled the dinornis and large quarternary birds of New Zealand. At this day it seems probable that the opinion of MM. Hébert and Lartet was correct.

Two years after M. Lartet described another large bird, of the softened miocene of Armagnac, the *Pelagornis miocœnus*, distinguished solely by a humerus a third longer than that of the albatross, and consequently of all living birds. The pelagornis approaches the longipennate palmipeds.

The comparative rarity of fossil birds in the marl-beds surprised M. Lartet. It is possible that on account of their peculiar organization they may have escaped more easily than other vertebrates the modifying influences of physical changes. Hence the great interest in studying them is to prove whether they are initially endowed with a specific power of longevity sufficient to continue them, by successive generations, down to the present time.

M. Lartet, after connecting his name with the discovery of the monkey of Sansan, had the good fortune to describe a new fossil animal of the same group, the *Dryopithecus Fontani*, found in the neighborhood of Saint Gaudens by M. Fontain. It was represented by a fragment of the lower jaw, and a humerus, and was found in a stratum with the macrotherium, the dicrocerus, and the rhinoceros, similar to those of Sansan.

The dentition of the *Dryopithecus* places it between man and the ape;

it ought, therefore, to be classed with the superior orders of the simian group, which include the orang-outang, the chimpanzee, the gorilla, the ape, and the *Protopithecus antiquus* of Sansan.

In the same basin of Garonne, M. Lartet discovered a new species of Sirenian fossil, the *Rytiodus*, whose enormously developed incisors seem to be related to the means of defense of the dugong. The classification of the fragments, collected at Sos (Lot et Garonne,) was attended with great difficulties, which were, I think, very skillfully overcome.

The collections of our associate included numerous remains of proboscidian fossils, (dinotherium, mastodon, elephant.) He saw the necessity of settling first their specific characteristics, and then of establishing their stratigraphical age. His undertaking was laudable and of unquestionable utility, since the teeth of the proboscidians are almost always found in the tertiary and quaternary deposits. It was first necessary to elucidate an obscure system of synonymy; then to show the dental formula of each species, to settle the question of the successive evolution of the teeth; to fix the time of the fall of the milk teeth, and finally to give the characteristics of the persistent grinders. Such was the work proposed by M. Lartet in his remarkable memoir upon the dentition of the proboscidian fossils, and the stratigraphical distribution of their remains in Europe.

He proves the probable existence of four species of dinotheria, notwithstanding the large number of species described, and in opposition to the opinion (held by several naturalists) of the union of these species into one. A beautiful fragment of a young dinotherium gave him an opportunity of observing the evolution of the teeth.

Among the six species of mastodons admitted by him he shows a new form, the *Mastodon Pyrenaicus;* the replacement of the teeth in the mastodons was exhibited to him by the jaw of the *Mastodon angustidens.* Among the elephants he recognizes four species identifying the *Elephas priscus* with the elephant of Africa.

The appearance of these fourteen proboscidians was anticipated in Europe by that of the rhinoceros. The dinotherium and the mastodon are found in the miocene period; but, while the dinotherium disappeared or becomes extinct in the miocene, the mastodon died out in the pliocene. The elephant born in the pliocene disappeared from Europe probably after the establishment of man in that country.

In 1856, M. Lartet gave, conjointly with M. Gaudry, an account of the fossil fauna of Pikermi. The importance of these collections of M. Gaudry in Greece are now well known; fifteen species of vertebrates, represented by thirty-three genera, have since been described in his article upon the fossil animals and the geology of Greece, but in 1856 the classification of the fossils had hardly commenced. There were numerous remains of monkeys, a careful examination of which proved hat the two species described by Wagner and Roth, under the names of *Mesopithecus Pentelicus*, and *Mesopithecus major*, were only the two sexes of the same monkey.

MM. Lartet and Gaudry mention a large edentate of Greece, like the macrotherium of Sansan; they also describe the *Thalassictis robusta*, the *Hystrix primigenia*, and give details in regard to several other species discovered by Wagner; but the most valuable facts brought to light by their article relate to two fossil giraffes, one of which afterwards became the type of the curious genus *Helladotherium*. They also pointed out the analogy between the fauna of Pikermi and that of Cucuron, and the excavations of M. Gaudry and Cucuron have since confirmed their views in this respect.

M. Lartet observed that with the most ancient ruminants of the tertiary period, that part of the molar-teeth which forms the enameled crown above the socket was shorter and projected less beyond the edge of the alveolus than with the quaternary ruminants or existing species of the same family.

M. Lartet concluded from this that the tertiary lynx, whose molars are not so long in the crown as in the animal now in existence, must have been shorter lived, since the duration of life necessarily depends upon the functional persistence of those indispensable organs of nutrition.

He also observed that in the old mammals the size of the brain was small compared with that of the head. Cuvier had before been impressed by the small relative volume of the brain of the anoplotherium, and supposed in consequence that the animal had very little intelligence.

The examples presented by M. Lartet in support of his thesis are conclusive. Thus, the *Brachyodon eocenus* of the eocene, the lophiodons of Issel, have brains smaller and less complicated than that of the *Caenotherium* of the lower miocene of Allier; the brain of the *Hipparion* has fewer convolutions than that of the horse; the wild-cat (*Viverra antiqua*) of the miocene of Allier has a cranial bone less voluminous than that of the living species, while its olfactory lobes are more developed.

The size of the cranium, considered in relation to the length of the enameled crown of the teeth, induced M. Lartet to suppose that the longevity of animals increases in direct proportion to the cerebral development, and consequently the animals now existing ought to live longer than their corresponding types in the ancient world.

I ought to mention among the researches of M. Lartet in regard to tertiary fauna, his latest work upon the *Trechomys Bonduelli*, a rodent of the size of a rat, from the upper marl of the gypsum of Pantin. Molars with a crown similarly formed may be found among existing rodents of the American type. Among fossil rodents which have some relation to the *Trechomys* may be mentioned the *Theridomys* and the *Isoptychus*.

In the calcareous formations of Gironde, M. Lartet mentions the unexpected association of a rhinoceros with an anthracotherium and a paleotherium. These fossils were discovered by M. Delfortrie, of Bordeaux.

The rhinoceros may be compared to the R. *latidens*; the anthracotherium to the *Hippopotamus leptorhynchus*, of Ronzon, near Puy-in-Velay; the paleotherium to a species of *Paloplotherium* of the calcareous deposit of Ronzon. The existence of the rhinoceros is thus carried back to the time of the paloplotherium. The same relations between these animals may extend to the beds of Hempstead, in the Isle of Wight, where there are hippopotami and paleotherians; also, to Bournocle Saint Pierre, where the *Rhinoceros Brivatensis* has been found associated with a paleotherium. Certain types of mammals which have been for a long time considered as characteristic of distinct tertiary periods ought now to be examined carefully with reference to the age of the deposits in which they are found.

III.—RESEARCHES RELATIVE TO QUATERNARY FAUNA TO THAT OF THE CAVES AND TO THAT OF THE PRESENT TIME.

The researches of M. Lartet in regard to quaternary fauna, to that of the caves, and to fossil man, added greatly to his reputation, and placed him among the most illustrious *savans* of our country. He did not seek celebrity; modest, conscientious, and burdened with the heavy responsibilities of an official position, he loved science for the pleasure it gives its votaries. His amicable relations with most of the naturalists of Europe was of great advantage to him, and his careful study of quaternary and tertiary fauna prepared him for the discussion of the great question of fossil man. It was, therefore, not surprising that he should have distinguished himself in this branch of natural science.

The memoir of M. Lartet upon the ancient migrations of the mammals of the present time may be considered as an introduction to the consideration of the fauna of the caves. According to his observations, the quaternary fauna includes two distinct zoological groups: The first is represented by the elephant of Africa, the two-horned rhinoceros, the hippopotamus, the lion, the panther, the serval, the striped hyena, the genet, the wild boar, &c., animals now nearly all African, which lived in Europe before, during, and after the great migratory phenomenon of the north.

The second zoological group is composed of mammals of northern origin, *Elephas primigenius*, *Rhinoceros tichorhinus*, and many species of Europe. A few of its representatives, the musk-ox, the lemming, the glutton, the reindeer, since the quaternary period, have migrated to subarctic latitudes; others, such as the *Elephas primigenius*, the *Rhinoceros tichorhinus*, *Cervus giganteus*, *Bos primigenius*, *Ursus spelæus*, &c., are generally becoming extinct, in accordance with the laws which control the longevity of individuals, and so limit the duration of species.

Truly an examination of the quaternary fauna is not less important than that of the periods which preceded and followed it, and we can well comprehend M. Lartet's opposition to the doctrine, then all-powerful, which reduced to a short period of physical convulsions, the time during which the quaternary species were developed. "This quaternary period," he says, "which is regarded by many as a sudden and violent transition from geological to present times has probably witnessed the development of millions of successive generations of the mammals which now inhabit Europe, and the day may not be far distant when the word cataclysm will be expelled from the vocabulary ot positive geology."

This theory in opposition to the great effect of cataclysms upon the existence of species was elaborated and supported by incontestable facts in "*some remarks upon the geological antiquity of the human species, in Southern Europe*," addressed by M. Lartet to the Academy in 1860, and printed in the *Bibliothèque de Genève.*

In regard to the discoveries of M. Boucher des Perthes, then greatly contested, M. Lartet considered that all doubt would be dissipated if traces of human action could be found upon the bones of the animals exhumed at the quartz works. He then sought for the quaternary bones described or mentioned by Cuvier, and found upon them very evident traces of the action of flint instruments.

The human race who worked the quartz of Amiens inhabited England and France were the same. The two countries were then united; their separation did not take place until after the deposit of the diluvial banks. After that event no great catastrophe occurred in Europe; the water courses may have been more rapid, but they did not overflow the limits of their present hydrographic basins. A dozen mammals, more or less, disappeared by gradual and successive extinction, and the greater part of the terrestrial population passed through the ordinary supposed changes of this long quaternary period.

From 1860 M. Lartet was almost exclusively employed in the caves, and we are indebted to him for interesting descriptions of Aurignac, of the Madeleine, of Laugerie, of the Eyzies, of Bruniquel, and of several other celebrated localities. It is difficult to give in a limited space an idea of the various matters discussed by M. Lartet in regard to these caves; questions which belong to ethnology, anthropology, primitive industry and even history; but I cannot pass over in silence the opportune intervention of paleontology in the chronological classification of the caves.

In looking over the list of the great quaternary mammals, it will be seen that eight or nine extinct or emigrated species have been found among the remains of the caves. Some of these have never been met with except in the lowest strata of these caves, where they have been succeeded by several zoological generations, while their presence in the oldest diluvium equally attests their age. Several successive periods may thus be distinguished during the time of the caves.

For instance, the *Ursus spelœus* seems to have appeared the earliest, and to have become extinct before the animals associated with it. The *Elephas primigenius* and its faithful companion, the *Rhinoceros tichorhinus*, are found in the diluvium, but are wanting in the peat, the kitchen refuse, the lacustrian habitations, &c. The reindeer, on the contrary, are still in existence, as also the urus or bison of Poland.

M. Lartet divides the period of primitive humanity into four ages: the age of the bear of the caves, the age of the elephant and of the rhinoceros, of the reindeer and of the Poland bison or auroch, but these systematic divisions are applicable only to a limited region. In Lithuania, the aurochs still exist, as in the time of Cæsar the reindeer was still an inhabitant of the hercynian forest.

Such were the facts disclosed by M. Lartet by his examination of the cave of Aurignac. In his other excavations all his sagacity was called into play by the figures of animals sculptured and engraved—the first artistic efforts of the men of the caves. It would be unjust not to mention in this connection the name of the English savan Christy, who displayed so much zeal in the explorations of Périgord, and who prepared, with M. Lartet's assistance, a beautiful work entitled "*Reliquiæ Aquitanicæ.*"

It was in association with M. Christy, that M. Lartet calculated the zoological population of most of the grottoes of Périgord. "A race, aboriginal or otherwise," he says, "inhabited this region in the same period with the reindeer, the bison, the wild goat, the chamois, animals, some of which have now representatives only in extreme climates, while a few descendants of others are found on the summits of the Alps and the Pyrenees. These people were not acquainted with the use of metals, they lived by hunting, and no animal was domesticated by them. Their sculpture indicates great artistic feeling."

We are indebted to this artistic talent for a very satisfactory representation upon an ivory tablet of the *Elephas primigenius.* This remarkable specimen came from the cave of the Madeleine. The figure of the reindeer is found engraved upon many of the bones from Périgord.

All the facts relative to the caves of the southwest part of France were to have been collected in a large volume by MM. Christy and Lartet, but unfortunately this interesting book was not completed, in consequence of the premature death of its authors. The parts published are filled with original research in regard to the caves of the valley of Vezere, the ancient fauna of Périgord, the grotto of Cromagnon, the exploration of which was made by a son of M. Lartet, and the human fossils of Cromagnon, &c.

M. Lartet also examined the bones of the caves of the Maritime Alps and of Herault. He found in the cave of Mars, about two miles from Vence, a new species of bear, strongly resembling in some respects the polar bear; this bear was associated with the leopard and the *Rhinoceros Merkii.* From the rhinoceros M. Lartet endeavored to determine the characteristics of the quaternary rhinoceros, of which the affinities are very obscure.

In conclusion I would call attention to a memoir upon the fossil musk-ox, a portion of the skull of which was found in the diluvium of

Précy, (Oise.) There was nothing peculiar in the character of this fossil; its classification was easily determined; but its presence in the quaternary period was a fact worthy the consideration of paleontologists. M. Lartet mentions as analogous cases the reindeer found at the foot of the Pyrenees; the sperm whale of the bone-pits of Montmorency, and that of the caves of Perigord, which resemble the American species; the bear of Canada, which is identical with the supposed agouti of the caves of Liége; the antelope found at Perigord; the desman, of Muscovy, in Norfolk, described by Owen under the name *Palæospalax magnus*, &c. Were these consecutive changes of habitation due to elective migration; to a forced retreat on account of the invasion of man, or to a gradual reduction of the species destined to become extinct?

This sketch of the works of M. Lartet, however incomplete, may give some idea of the character of his mind. He was to the last degree careful and accurate in the examination and classification of fossil specimens; but their character once established on a firm foundation, his ingenuity, his patience, his originality, and power of close observation frequently from facts apparently the most sterile, developed very unexpected and interesting results. The definition of genius, as applied to a well-known naturalist, "genius is patience," was fully exemplified in him, and he was never more patient than during his excavations in the caves, while in his application of paleontology to the classification of the fossil specimens found there, he truly acted as a pioneer in this branch of science.

In the latter years of his life M. Lartet, whose modesty equaled his wisdom, received many marks of honorable distinction. He was elected to preside over the Geological Society in 1866; shortly after the Anthropological Society gave him the same testimony of esteem. He was made President of the International Archæological and Prehistoric Anthropological Congress, which was inaugurated at Paris in 1867, and which claimed the honor of having originated theories in regard to fossil man. He was appointed a member of the commission for the *History of the Transactions* of the Exposition of 1867, and took an active part in the organization of the very interesting anthropological galleries. He rendered important assistance in the formation of the museum of Saint Germain, and was made an officer of the legion of honor at time of its inauguration. In 1869 he was elected by the professors of the museum to the chair of paleontology, made vacant by the death of M. d'Archiac, whose loss was deeply deplored and whose memory will always be venerated by the Geological Society.

M. Lartet was sixty-eight years of age when he entered upon his professorship; he had never undertaken a course of public instruction, and felt the importance of the task imposed upon him. He prepared a certain number of lectures, but unhappily, to his great regret, his health, already impaired, prevented a full exposition of his views in regard to tertiary fauna. His physicians soon interdicted all intellectual work and recommended his return to his native air as the only hope of recovery. He left Paris in the early part of August, a prey to the most gloomy presentiments, and had hardly arrived at Gers, near Sansan, the scene of his former labors, when he was heart broken by the national misfortunes of the French, at the time of the foreign invasion; his strength failed rapidly, and he expired on the 28th of January, 1871, less than two years after his appointment by the museum, bequeathing to us an example of a life honorable, disinterested, and entirely devoted to science.

THE SCIENTIFIC EDUCATION OF MECHANICS AND ARTISANS.

AN ADDRESS DELIVERED AT THE ANNUAL COMMENCEMENT OF THE WORCESTER (MASSACHUSETTS) FREE INSTITUTE OF INDUSTRIAL SCIENCE, JULY 31, 1872.*

By Professor Andrew P. Peabody, of Harvard College.

Many years ago there was a strong feeling throughout New England in behalf of manual-labor schools (so-called.) I think I am right in saying that the experiment, wherever tried, failed. The reasons are obvious. The labor was not skilled labor, and therefore gave no mental revenue, and very low wages. It was merely a clumsy endeavor to enable poor young men to pay by the least remunerative kinds of work for their board and tuition at a half-time school. The hand-labor not only taught them nothing, but stupified those of them for whom that work remained to be wrought. Most of them, however, started with not a very large or active brain-capital; for so slow and limping a gait had few attractions for youth of genius or ability.

This institution is at the broadest remove from those, in theory and in practice. Its name so implies. It is an institute of industrial science. Its labor is brain-work; its machine-shop is a recitation-room; its mechanical processes correspond to the collegian's drawings on the blackboard; its finished products, to his corrected and approved diagrams. Its object is to train liberally educated mechanics and artisans—men who shall start in life with progressive ideas and the power of rapid self-advancement; who shall diffuse intelligence while they create values; who shall adorn as men the society which they enrich as operatives; who shall have, independently of their callings, a selfhood immeasurably more precious and more honorable.

In addressing the students, graduates, and friends of this institution, I have chosen for my subject the worth of an extended education to mechanics and artisans.

Suffer me to begin with the lowest consideration, that of money's worth—the lowest as it is commonly called, yet by no means to be despised; for though we have the best authority for saying that "the love of money is the root of all evil," this love and the sordid qualities which it implies and engenders are, I think, oftener produced by pinching penury than by earned and merited prosperity; while the position, influence, and capacity of usefulness which money confers are worthy of every man's strong desire and honest endeavor. Especially do they suit the ambition of him who may hope to enrich himself by the creation of values, and not by speculating upon them.

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* Furnished by the author for publication by the Smithsonian Institution, at its special request.

Let us analyze the price of a finished commodity. Here is a lathe, or an air-pump, or a steam-engine, held at a certain price, which, where competition is free, very nearly represents its exact value. That value is composed of three parts: the wages of labor, the wages of skill, and the reimbursement and profit of capital.

The wages of labor, that is, of mere physical force, or of processes which require no knowledge or discretion, constitute the smallest part of this value. Labor can never earn more than a mere subsistence, nor ought it to earn more. Left to itself, it cannot produce more than enough to sustain a meagre, starveling life. The aborigines of North America had dwelt on this soil for hundreds, perhaps thousands of years, yet had not only accumulated no wealth, but were unable, except at rare intervals, to secure a satisfying supply for the rudest wants of nature. A New England farmer, even with the ownership of his land, if he apply no skill or science to his farm, though he, his wife, and his children toil incessantly, can obtain barely the necessaries, hardly any of the comforts of life. Now, the wages of labor must be measured by its products, and by this measure will generally fall short of the cost of comfortable living. They somewhat exceed this standard in our country at the present moment. The reason is that in the development of our resources, the construction of railways, and the opening of fresh soils, the demand for manual labor keeps a little in advance of the supply. But what mere bone and muscle can earn in an old and settled community, what their earnings tend to become and may very soon become here, may be learned by the wretched pittance of English operatives, not sufficient to save their families from a death-rate which shows that poverty is no less destructive than pestilence.

Moreover, low as these wages are, the tendency in a fully-settled country is to a still farther decline. Though production may increase, the demand for unskilled labor diminishes. The time was when all work was done by hand. Now, machinery driven by steam or water-power supersedes the greater part of hand-labor. All the strong men in the habitable world could not exert the amount of physical power which is at this moment at work in the little island of Great Britain. The substitution of machinery for human strength is still going on. Steam is replacing even the shovel and the pickaxe; and the time will come when the Briarean steam-engine, with its fireman and feeder, will everywhere do the work which a hundred arms do now. The supply of labor thus tending constantly to exceed the demand, its wages must sink very nearly to the starvation point.

The second part of the price of a manufactured commodity is the wages of skill. This is distributed among the workmen employed, in proportion to their respective degrees of skill. He who can work only as a journeymen under the direction of others, or who can perform but a single and not very difficult process in a complicated piece of work, receives a somewhat higher compensation than he would get for carrying a hod or shovelling earth, and this slight advance is the price of the imperfect training and the moderate degree of brain-power which he puts into his work. He, on the other hand, who understands every part of his business, who can knowingly direct the labors of others, who can insure for the articles of his manufacture the highest reputation, and can be relied on for the fulfillment of his contracts, can obtain a price fully proportioned to his superior skill and ability. His income is a compensation for the amount of labor which his skill supersedes. A part of the saving inures, indeed, to the public in the cheapening of the commodities produced, but a large portion becomes the legitimate recompense of his own skill. Competition will prevent his receiving more than he fairly merits. The master-machinist or manufacturer, who has some hundreds of operatives under his employ, even though he have twice or three times the salary of the governor or chief justice of the State, earns all that is paid to him, and is at the same time a public benefactor to a very large extent; for the commodities that he furnishes would, under a less skillful superintendence, be produced at a much greater cost. But for skill like his, clothing and furniture, that are now within every one's reach, would be too expensive for the means of any save the richest purchasers.

But this skill, except in the rarest instances of mechanical genius, is to be acquired by education alone, and not by the mere training of the hand, but equally of the brain. The skilled laborer cannot dispense with the knowledge of chemistry, physics, and mathematics. By chemistry he must learn the properties of materials, their proportions and laws of combination, the action upon them of oxygen and hydrogen, of heat, light, and electricity. By physics he must become acquainted with the mechanical powers, the strength of materials, the effect of friction, the constants and variables which must always be taken into the account to prevent either the deficiency or the waste of force. But physics is a mathematical science, and chemistry has become one; indeed, till it was one, it hardly merited the name of science. Without a very thorough mathematical training, neither chemistry nor physics can be so understood that the artisan can have a fair command of his materials, instruments, and forces; can meet unexpected exigencies; can avail himself understandingly of improved processes; can calculate results, economize resources, and give his products their highest degree of perfection. Then, too, the skilled artisan needs general culture. He is to conduct correspondence, to treat on equal terms with men of intelligence and education, to maintain in society a position worthy of respect and confidence, to do his part toward raising his special calling to the rank of a liberal profession; for this is what the various departments of mechanical art ought to be, and they will be thus called and recognized, so far as their professors show themselves men of liberal nurture.

The third part of the cost of a commodity, is the reimbursement and profits of the capital expended in buildings, machinery, and raw materials. Capital is, in fact, the accumulated savings of the wages of skill. Labor creates all values. But, as we have seen, mere hand-labor can no more than support the laborer; it leaves no surplus to be saved. Skilled labor, on the other hand, creates more value than the laborer consumes, and the surplus remains in hand—in the ruder states of society, in such wealth as can be locked up in coffers, ward-robes and granaries; in a more advanced community, in such forms as admit of its expenditure in industrial operations. By laws, which I have not time to expound, but as inevitable as those by which the little streams of a valley lose themselves in the river that drains it, small capitals tend to run together, and thus to form the large capitals, which are the object of so much senseless jealousy and hostility. These large capitals are indispensable to the stability of industrial operations; for even in the most lucrative descriptions of business there are not unfrequent seasons of stagnation and reverse, which would be ruinous, were there not capitals ample enough to keep the wheels of industry in motion without immediate revenue.

Capital ought to earn much more than the mere support of its holders and managers. It ought to have such profits as will lead to its own large annual increase, which is needed, in part, to replace the immense amount of property annually destroyed by fire, storm, shipwreck, and disaster, and, in part, to meet the essential outlays for the industrial demands of a population growing rapidly, both in number and in wants. Here let it be remembered that all capital, in order to yield a profit, must be used for industrial purposes. The hoarding of it is a mere fiction. It must all be worked over, and the labor and skill which it employs must be paid for before the capitalist receives the first dollar of his income. It will be observed, also, that large capitals, so far from superseding, utilize, protect, and cherish small capitals, however invested, whether directly in industrial enterprises, or indirectly through banks; and while the absorption of small capitals is constantly going on in a healthy condition of society, their creation is more rapid than their absorption, as in a rainy season the brooks and streams receive from the heavens more water than they can carry into the river.

Now the point which I wish to urge is this: By the education given here, the mechanic or artisan is enabled to secure for himself at once the wages of labor which will feed and clothe him, the wages of superior skill which will yield him a surplus revenue, and the profits of capital, by the investment of his savings year by year, and of the constantly increasing income of those savings. This, indeed, is the proper way of settling the conflict between labor and capital. Every skilled laborer belongs to both parties, and in fighting against capital he is at war with himself. If he begins life poor, his interest may, indeed, then seem to be on the side of labor; but with every year's savings it is more and more for his interest that capital should yield a remunerative income, and the very measures which, if successful, would impoverish the millionaire, would render his modest surplus earnings unproductive and their investment insecure. The graduates of this institute may regard themselves as capitalists in the near future; for the brain-power that is furnished here is the very material from which wealth is created. Were I familiar with the names in Worcester, I know that I could point out to you not a few of the proprietors of these great manufacturing establishments, who came hither with no resource except hands and brain, and have fairly earned, by industry and skill, every dollar of the tens and hundreds of thousands which it may be literally said they are worth; for, though a man may not be worth all the money he has, he is worth all that he has honestly acquired.

But there are higher grounds on which institutions like this should be cherished. We are training in our schools of industrial science discoverers and inventors in their several departments—men who will shorten and cheapen the labor of production, introduce new applications of science to the useful arts, and add permanently to the wealth of humanity by industrial improvements.

There are some families in the vegetable creation—diœcious, so called—in which the fructifying pollen and the fruit-producing blossome are elaborated on different plants. Similar has been the case, for the most part, in the industrial world. Inventions have generally been the joint product of two very different classes of minds, neither of which could have effected anything without the other; and, not unfrequently, between the two an important invention has been kept for many years in abeyance, and, when finally perfected, has been of doubtful or disputed parentage. The germinal idea or principle has been conceived and suggested by a man of learning, science, and studious and reflective habits, but of no practical skill. He has tried in vain to embody it; has encountered, it may be, ridicule, opposition, contempt. Perhaps, after years of fruitless endeavor, he has lapsed into unhonored penury or death. His idea has been taken up by some man who had the skill to actualize what he had not genius or knowledge enough to originate, and he has reaped the honor and the profit of his predecessor's uncompensated study and toil. As by the old slave-law the child follows the fortunes of the mother, so the invention—the brain-child—is, by geneneral consent, accredited, not to the fertilizing mind, but to the producing hand.

An obvious instance may be found in the history of the application of ether as an anæsthetic agent. You know that Drs. Jackson and Morton both claimed the invention, and both, I believe, with equal truth, though by the law which I have specified the right was Morton's. Jackson conceived the idea, for which Morton's scientific knowledge was inadequate. Morton contrived means for the successful experiment, for which Jackson's practical skill was inadequate. Had Jackson been a practising dentist as well as a chemist, or had Morton been a scientifically educated man as well as a dentist, either might have borne the undisputed honor of discoverer and inventor.

In a certain sense inventions are said to be the work of their age rather than of individuals; but they have generally been a little behind their age. A new and fruitful idea has commonly been current in the scientific world for a generation or more, before it has been actualized, and this for the simple reason that the scientific men have not had the skill requisite for successful experiments, and the men of practical skill have not had science enough to recognize and welcome the dawning of any new light. Thus, an invention of prime importance has often hovered long within the near reach of both speculative and practical men, waiting for that conjunction of science and skill without which it could not assume an available form; and when it has been at length brought forth, many had approached so near it and had so distinctly anticipated it as to claim with entire honesty the merit of its inception.

The history of steam-power affords numerous illustrations of the principle which I have ennunciated. A full century of experiments by speculative philosophers on steam as a working force had elapsed—with the construction of various forms of machinery, which demonstrated its potential efficacy, yet were too cumbrous, or too frail, or too restricted in their range of work to be put to any use, except for pumping water from mines—when the steam-engine, with its cylinder and piston separate from the boiler, came from the hands of Newcomen, the blacksmith, and Cawley, the plumber, about the beginning of the last century. Some sixty years later, Watt conceived the idea of a separate condenser, to save the loss of power and the waste of fuel by the alternate heating and cooling of the cylinder—a contrivance which alone and at once placed steam in advance of all other mechanical agencies, and gave sure presage of its enduring and world-wide supremacy. But he, though a mechanical genius of the highest order, was hardly more than a self-taught workman, having had but a single year's apprenticeship to a London mathematical-instrument maker. His conception and foresight of his great invention were clear and vivid; but his own working-power was very limited, and in all Glasgow he could not find artisans capable of the delicate workmanship required, the collective skill of the city not sufficing for the casting and boring of a cylinder, while a hammered cylinder left fatal interstices between its inner surface and the piston. After fourteen years of speculation and experiment he had got no further than to show that he ought to have succeeded, and was yielding to despair under the pressure of poverty and repeated failures, when he entered into partnership with Boulton, a trained and skilled manufacturer in iron and steel, in Birmingham, the emporium of skilled labor for the British Empire. Under these new auspices his progress was a continuous triumph—a triumph which, however, was his, only because his partner was a just and true-hearted man; for it is under precisely such circumstances that in numerous instances the actual inventor has succumbed to the skilled and able artisan, while Boulton left to Watt the fame that was his rightful due, and took care that his long years of toil and want should be crowned by an old age of ease and affluence.

Attempts at navigation by steam were made at intervals for a century and a half, or more, but generally by men who had more science than art; often by those who had neither, but only a vague conception of the capacity and destiny of this mighty agent which was to inaugurate a new era for human industry and enterprise. Some of these experiments were partially successful, yet failed to combine the essential conditions of power, speed, manageableness, and durability. Fitch, had he been a well-trained mechanician, would undoubtedly have antedated by several years the establishment of steam-navigation on our western waters. But the glory was reserved for Fulton, who, though not educated as a mechanic, had made himself one by taste, study, and matured practice, and was as familiar with the details of material, method, and workmanship as with the scientific conditions to which all these are subservient. Yet even he was retarded in the successful execution of his plans by the fact that he was not by profession a machinist or a ship-builder. The idea, full grown and available, preceded its final embodiment by at least fourteen years, an interval in which he had experimented in France under disadvantages and discouragements that would have been fatal to the scheme, but for his indomitable elasticity and hopefulness. Had he been master of a machine-shop or a building-yard of his own, he would undoubtedly have launched the Clermont not later than the first year of this century instead of the seventh, and would have been spared the litigations with rival claimants which imbittered the residue of his life, and hastened its close, leaving, as his biographer says, for "the only patrimony of his children, the load of debt which their parent contracted in those pursuits that ought to command the gratitude, as they do the admiration of mankind."

Of the disabilities under which an inventor may labor in consequence of his not being an artisan by profession, we have a striking illustration in Eli Whitney, the inventor of the cotton-gin. In his case the conception and the execution were united. He was a man of thorough literary and scientific education, and at the same time of a native mechanical genius, which attested itself in his very boyhood by the manufacture of tools, cutlery, and musical instruments, of peculiarly good quality and finish. After graduating at Yale College he went to Georgia under an engagement as a teacher. Cotton was at that time almost worthless as a staple of agriculture and commerce, as it could be cleaned from the seed only by hand, at the rate of a pound of the gross cotton per day for each laborer. He saw at once the possibility of performing this process by machinery, and constructed a rude and imperfect model, worked by hand, which turned out fifty pounds of the cleansed staple per day. But he found in Georgia neither the workmen nor the materials for perfecting his invention or for multiplying his machines. It took him years to get the manufacture well under way. Meanwhile, in the eagerness for the use of this wealth-yielding process, his patent-rights were ignored; cotton-gins embodying his principle, with trivial variations, were multiplied; the interest of intrusive manufacturers and that of the planters who adopted their contrivances, and thus laid themselves open to legal prosecution, were arrayed against him, and elicited a strong public sentiment to his prejudice; sixty suits were instituted before he obtained a single legal decision in his favor; and his invention, which at once raised the whole southern section of the country from thriftless poverty to abounding opulence, was to him never worth the parchment on which his patent was engrossed.

Now the effect of institutes like yours is to replace the diœcious by monœcious trees—to have the pollen and the fruit-buds grow on the same stalk. You have here, students and graduates, all that careful training can do for you to make you discoverers and inventors—to enable you both to initiate and to actualize industrial improvements, and to reap, without hinderance or rivalry, your merited honor and recompense. Moreover, nothing less than this training can put you on the arena with the promise of success. No accurate practical results can be reached without the most exact calculations; for, whether man know, or be ignorant of, the laws of number and proportion, all substances and forces in nature obey them, and man masters nature only by making them his rule and measure.

Your literary education here tends in the same direction. Especially is this true of the command you acquire of the French language. He who would contribute to the industrial advancement of mankind must know what others have thought and done, how far each separate art and science has advanced, what unsuccessful experiments have been made and therefore need not be repeated, and in what directions men of learning and skill are looking for the new light of which they may unconsciously be the harbingers; and the French has been for more than a century the mother-tongue of science and the useful arts, abounding equally in encyclopedic works and in monographs, and presenting the most advanced views in every department of physical philosophy and of practical technology.

With these exercises of the school-room you have the education of the workshop, far more systematic, comprehensive, and exact than could fall to your lot under the best private auspices. You thus will be prepared to execute or direct your own plans, to embody your new thought in wood, steel, or brass, and to insure for yourselves a fair trial of whatever process or agency may seem to you an improvement on the past.

Think not that the canon of inventive genius is closed. It is but just opening. Agents may be slumbering unrecognized that shall supplant those now in the ascendant. Steam—the sovereign of our time—may yield the sceptre to a mightier energy. The power now obtained by the holocaust of forests and the disemboweling of the solid earth may be replaced by some one of those elementary forces which "spread undivided, operate unspent." The general use of condensed air for purposes of locomotion by land and water is now as probable as that of steam was a century ago; and Ericsson has advanced as far in the former as all the predecessors of Fulton had done in the latter. How know we that the electro-magnetic force which we have harnessed to our thought may not one day be yoked to our railway trains? Who can say that the pretended generation of light and heat for common uses by the decomposition of water (the rumor of which, if I mistake not, emanated from this very city,) while an audacious imposture, may not have been an unintended prophecy? Who knows but that the still deficient directing and impelling force may yet be so applied as to give certainty and calculable utility to aerial navigation? Then, too, in many of our established processes, machines, and modes of locomotion there are still limitations, liabilities to accident, possibilities of added speed or efficacy, in fine, a thousand directions in which inventive talent may be fruitfully busy. Nor is there any invention, however insignificant it may seem, which multiplied, as it may be, by thousands or millions, and extending into an indefinite future, may not carry with it an untold saving of cost and labor, and in many cases, even of life. The invention which in the least degree facilitates industry, and increases and cheapens its products, is a benefaction to society which will immeasurably outweigh and outlast the most munificent gifts that wealth can bestow. It is by such charities that many of you, I trust, will do honor to your calling as liberally-educated artisans.

Permit me now briefly to advert to the need which our country has of institutions like yours. Nothing is more evident than the overcrowding, at the present time, of every department of commerce. Up to a certain point commerce is, like the mechanic arts, a creative profession. A commodity is not a finished product till it is brought within easy reach of its consumer, and the merchants—wholesale and retail—who are needed for the successive stages between the producer and the consumer are to that extent co-agents in the production, as are also the bankers and brokers who supply the necessary funds and facilitate the essential pecuniary arrangements. But when members of the mercantile profession are so needlessly multiplied that they create supernumerary stages in the passage of goods from the producer to the consumer, interpose to arrest instead of facilitating their transfer, levy black-mail on every commodity in the market, and get for themselves the lion's share in its ultimate price, they then inflict a grievous wrong on both parties—they make their superfluous profit on the spoils of both; on the one hand scanting the wages of productive industry, on the other hand cramping the consumers' purchasing power.

That this is the condition of things in our country at the present time, there can be no doubt. The reason, too, is obvious. Our schools educate our young men to a point at which they feel that they sacrifice their self-respect and sink beneath their proper level by becoming mere laborers, or mere routine-mechanics, especially when they are thus placed by the side of, or brought into competition with, the hordes of uneducated and rude immigrants that crowd our labor-market. Those who were themselves content with hand-labor are ambitious of a higher destiny for their sons. Hence the rush into commerce. Hence the scores of applicants for every vacant clerkship. Hence the spectacle—equally ludicrous and sad—of hands that could wield the sledgehammer, measuring tape, drawing soda-water, and weighing sugarplums. Everything that can by the broadest construction call itself trade or commerce deems itself respectable; and therefore our towns and cities are supporting twice the number of shopkeepers that they need, and sustaining able-bodied men, too, in paltry commercial industries, which yet would give a competence to our thousands of starving women and girls.

To restore the deranged balance of society, its old honor must be rendered back to labor. Industrial pursuits must be raised in respectability and dignity above the lower walks of commerce, and fully to a level with its higher departments and functions. Both agriculture and handicraft must be made liberal professions. This can be effected only by stocking them with men of liberal culture; for it is not the profession that gives character and standing to the man, but the man to the profession. Our agricultural colleges and our industrial institutes are supplying the needed culture, and are going to replenish the field and the workshop with a new order of large and high-minded operatives, men of liberal tastes, pursuits, and aims, who will do honor to their respective callings, and make them seem worthy the noblest ambition of the aspiring youth of the coming generation. The successful impulse has been already given. It is already no uncommon thing for the graduates of our best colleges to pass at once into the machine-shop or the factory, and to go through the entire novitiate as a raw apprentice might. It has, indeed, been demonstrated, and it will soon be made apparent to the whole world, that there is no department of productive industry in which genius, talent, science, and learning may not find fit investment, ample room to grow, and adequate social position and honor.

There are other points to which I would gladly ask your attention had I not taxed it so long. But I cannot close without reminding the students and graduates of this institute that education has, or ought to have, a higher use than what we call its use. We are too apt to think of the course of early study and discipline, chiefly as a specific preparation for one's business or calling in after-life, as the means of becoming a good lawyer or physician, merchant, mechanic, or farmer. This, however important, is but a secondary purpose. You might better be, my young friend, a beaver or a sparrow, if skill as an artisan or a fabricator seems to you the great aim and end of life. Over and above your profession, exceeding it, mastering it, should be your selfhood, your manhood, your being as a thinker, a knower, a member of human society, a child of God, an immortal soul. Your course of instruction here has its highest value in giving you real knowledge, materials for thought, stimulants to mental activity, and, withal, food for your moral, spiritual nature. In the laws of the material universe, and especially in the necessary and eternal laws that underlie all mathematical science, you enter into close contact—I would that you might ever know and feel it—with the Infinite mind; you become conversant with forces which are but the multiform, yet undivided, Omnipotence. In the study of physical science you are within temple gates and on holy ground. Let then these pursuits into which you are here initiated for a life-long self-training, vindicate their claim to be regarded as liberal studies by the breadth and depth of thought, sentiment, and character which they inspire and cherish, by the high type of manhood which they foster, by the noble lives to which they give the impulse.

Remember, above all, that your ultimate success depends on character. Genius and skill, unsustained by character, will but glitter and vanish. Industry, probity, chastity, sober habits, a quick and healthy conscience, are worth fully as much in the mere material interests of a life of average duration as they are in the judgment of God and in the esteem of good men. Young persons are very apt to discriminate between preparation for this world and preparation for the world to come. To one who has lived as long as I have, the two seem identical. Could I start at your age with the fruits of my three score years of observation and experience, I should take precisely the same route to the surest and highest earthly success, emolument, and honor, which I would take as the nearest way to heaven.

ORGANIC BASES.

LECTURE DELIVERED BY PROFESSOR A. BAUER BEFORE THE VIENNA SOCIETY FOR THE DIFFUSION OF SCIENTIFIC KNOWLEDGE.

[*Translated for the Smithsonian Institution.*]

Although bodies having the properties of acids, as, for instance, tartaric, citric, and malic acids, had long been known to exist in certain vegetable and animal substances, it was reserved for our century to discover bodies of alkaline or basic properties in the organic world. A chemist, Sertürner by name, first succeeded in isolating morphine from opium, the long-known juice of the poppy, obtained by making incisions into the capsules, and afterwards drying the product in the air.

Little attention was at first paid to this discovery, because all the energies of chemists had been turned to the study of inorganic chemistry; it was out of the regular line of research at the time, and, therefore, remained isolated and unappreciated. When, however, several years later, Gay Lussac showed the importance of Sertürner's discovery, and proved himself, in a dissertation published in 1816, that morphine acted like an alkali in regard to vegetable colors and acids, his work became the incentive to a search for similar bodies in such plants as were known for their sanative or poisonous effects. In many cases their active principle was found to consist in an alkaline substance, combined with an organic acid, and hence called an alkaloid.

Pelletier and Caventon found alkaloids in Peruvian bark and in the strychneaceæ, and in 1826 Unverdorben succeeded in artificially preparing several alkaloids or organic bases by the dry distillation of horn, bones, and other animal substances. These discoveries gained for organic bases a place among the most important and interesting bodies in chemistry, and many chemists devoted themselves exclusively to their study. Theoretical considerations concerning the nature of organic bases caused their more extended investigation. These theoretical consideration were founded upon the interesting fact of the similarity of all these bases to ammonia. In the natural alkaloids the similarity consists chiefly in the chemical equivalents, but in the artificial bases lately discovered it is also exhibited in their physical properties.

These facts have led to the supposition that there exists an intimate relation between the organic bases and ammonia. Berzelius, indeed, suggested the probability of the pre-existence of ammonia in all these bases; while Liebig, in the first volume of his Dictionary of Chemistry, (Handwörterbuch der Chemie,) developed a theory concerning their constitution, which forms the basis of our present views as to this interesting branch of chemistry. He assumed that ammonia was the type of all organic bases, and that it was itself such a base, of the simplest composition. Ammonia consists of only two elements, containing one atom of nitrogen and three of hydrogen in one molecule.* Liebig assumed that, in the organic bases, a part of the hydrogen was replaced by other radicals, composed of several elements; these bases might therefore be considered as made up of a compound radical and a combination of one atom of nitrogen with only two of hydrogen, the other atom of hydrogen being replaced by the new radical. The compound thus formed is called amid.† Such a base is called an amid base.‡

Liebig developed this idea in the clear and ingenious manner peculiar to himself, and expressed his views concerning the probable nature of compounds which could be formed from amid and the alcohol radicals. Ten years later his ideas were verified by experiment. Ethylamine, and a whole series of similar bases, were produced by Wurtz in Paris in 1849.

These discoveries of the celebrated French scientist justly excited unusual attention, which was still increased when A. W. Hofmann and Wurtz demonstrated that not only one atom of hydrogen in ammonia could be replaced by an alcohol radical to form amid bases, but that compound radicals could be substituted for two, and even for all three, atoms of hydrogen. These bases might be designated as primary, secondary, and tertiary amid bases, according as one, two, or three atoms of hydrogen of the ammonia have been replaced by compound radicals. (In English treatises on chemistry they are usually designated as amid, imid, and nitril bases.—*The Translator.*) Their chemical formulæ are represented by the following table, in which A, B, C, stand for the compound radicals.

Ammonia base.	Amid base.	Imid base,	Nitril base.
$\left.\begin{matrix}H\\H\\H\end{matrix}\right\}n$	$\left.\begin{matrix}A\\H\\H\end{matrix}\right\}n$	$\left.\begin{matrix}A\\B\\H\end{matrix}\right\}n$	$\left.\begin{matrix}A\\B\\C\end{matrix}\right\}n$

As Hofmann has shown later that there is a series of compound radicals which may replace two atoms of hydrogen in the doubled formula of ammonia, producing a second extensive series of bases, whose composition is expressed in the following table, where A^1 B^1 and C^1 represent the compound radicals.

$\left.\begin{matrix}H_2\\H_2\\H_2\end{matrix}\right\}n_2$	$\left.\begin{matrix}A^1\\H_2\\H_2\end{matrix}\right\}n_2$	$\left.\begin{matrix}A^1\\B^1\\H_2\end{matrix}\right\}n_2$	$\left.\begin{matrix}A^1\\B^1\\C^1\end{matrix}\right\}n_2$

If we suppose only 52 such compound radicals capable of replacing one atom, and 32 of replacing two atoms of hydrogen, we obtain 35,000 millions of possible compound organic bases.

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* The symbol N, (nitrogen,) in chemical formulæ, means one atom of nitrogen, and H one atom of hydrogen. The formula for ammonia is therefore: $H+H+H+N=H_3N$.

† The chemical formula of amid is therefore: $H_2\,N$.

‡ The formula for an amidogen base is: $A+H_2\,N$, in which A stands for a compound radical.

This enormous number shows how impossible it is, in spite of the most persevering labors, to become acquainted with more than a very small proportion of these compounds. This very number urges us to study only the prominent representatives of whole series, and to give to them our whole time and energies.

From what has been said in regard to the composition of organic bases, it was thought evident that nitrogen would appear to be the component on which their properties depend, for they all contain nitrogen. But we know now whole series of analogous bases containing, instead of nitrogen, some other element of similar properties. These also have the characteristics of ammonia. As early as 1846, Paul Thenard had made phosphorus bases, which were more thoroughly investigated in 1855 by Hofmann and Cahours. Analogous arsenic bases have been known much longer. In 1760 Cadet prepared one, the composition of which he could not, of course, explain. The investigations of Bunsen, from 1837 to 1843, shed more light on this remarkable class of organic bodies, and the constitution of the arsenic bases was finally completely made clear by the researches of Cahours, Kolbe, Riche, and especially Baeyer, in Berlin. In 1850 Löwig discovered antimony and bismuth bases, so that we now have four other elements capable of forming whole series of basic combinations like those of nitrogen. Compare these with the above-mentioned number of possible nitrogen bases, and we will be convinced that the chemist as well as the astronomer is able to astonish us with magnificent numbers, and to call up before the mind's eye endless series of possible combinations, all producing bodies having special qualities..

However much these researches have extended our knowledge, they have but slightly improved our acquaintance with the bases and alkaloids spontaneously formed in nature. The constitution and the relations of these natural alkaloids to the other bases and to other chemical compounds are much less understood than the foregoing statement would lead us to suppose. The causes of this are that the natural alkaloids are mostly very complex bodies, and that they suffer such complete changes in most reactions, that it is difficult to study them, or to form any conclusion as to the constitution they had before they were decomposed. It must be left to the future to shed more light on the nature of these bodies. Let us hope that it will be possible to make those alkaloids synthetically which have hitherto been found only in nature. We must not forget in this connection that most of the natural bases contain oxygen, which is not found in the ammonia bases. Although the discovery of the so-called ammonium bases, and Wurtz's beautiful discovery of the behavior of oxide of ethylene to ammonia, have indicated the way of preparing such oxygen bases artificially, there is nevertheless a difficulty, which seems almost insurmountable. It is the fact that most of the natural bases have optical properties, while we cannot succeed with the aid of the above processes in preparing compounds possessing similar properties from substances not originally possessing them. The discovery of methods for the artificial or synthetic preparation of the alkaloids would not only be of high scientific interest, but it would also greatly advance our material interests, for there is scarcely another group of bodies of such manifold uses as the organic bases.

Many of these alkaloids play an important part in the arts, others are known as the active principles of stimulating articles of food, while the great number of them are valuable as medicines. Many of them are extremely violent poisons, and have acquired an unenviable reputation from cases in which they have been employed.

Poisoning by means of vegetable bases is rendered doubly dangerous, because it is often difficult to prove with certainty the presence of the poison in the corpse or the secretions by chemical analysis, while the presence of mineral poisons can generally be detected with ready certainty. The reason of this is not difficult to understand. We are but imperfectly acquainted with the properties of the natural alkaloids. They resemble each other very much. In cases of poisoning, they are mixed up in the stomach or other parts of the body with many other organic substances, all containing carbon and having certain properties in common with them. These organic substances are of course more akin to the vegetable bases than to inorganic substances, such as the compounds of arsenic, which are not found in any part of the human body. Metals are present only in insignificant quantities, and those which are present are not at all similar to arsenic. Now the organic bodies present all contain nitrogen and may have basic properties, both characteristics of alkaloids. It is obvious that the detection and separation of very similar bodies are much more difficult than the separation of dissimilar ones, where the detection of a single property often suffices to prove their presence with certainty.

If we consider furthermore that the alkaloids are very easily decomposed, and that in legal chemical investigations the bodies in which they are to be sought for are generally in a state of putrefaction, *i. e.*, of continual active change, we will understand how impossible it is frequently for chemists to separate the poisons in a state of purity from parts of the body and to prove their presence with certainty. It is indeed sometimes possible to inject the substances which in cases of poisoning must contain the vegetable base, into the blood of living animals or to mix it with their food, and then to judge, from the physiological effects on the animals, which poison was present. The changes produced by certain alkaloids on the beating of the heart, on the general action of the muscles, and on the nervous system, are frequently so characteristic that we can judge of the presence of one or other alkaloid with as much certainty from these effects as from pure chemical reactions. Such proofs, however, have not the full force of evidence in court, for in such cases the separation of the pure poison must always be the chief aim of the chemist.

Dangerous as our organic bases may become in the hands of the murderer, they are highly salutary in the prescriptions of the physician, who employs them with great success in the treatment of severe and otherwise unyielding diseases. Peruvian bark owes its efficacy to the alkaloid *quinine* which it contains together with *cinchonine* and *chinidine* in varying proportions. Formerly, before these facts were known, there was no standand by which the value of different specimens of Peruvian bark could be correctly judged. Sometimes a certain kind of bark, whose dose had been fixed by experience, acquired a much greater value than others whose efficacy far surpassed it. Now the value depends on the amount of bases contained in the bark and not on the color, shape, or other external signs. Not the smallest piece of the bark is now allowed to be lost on gathering it, because processes are known by which even the smallest quantity of quinine contained in it can be obtained.

The same is true of different kinds of opium. Their medicinal value depends on the amount of alkaloids they contain. These are *morphine*, *codeine*, and *narcotine*, three beautiful crystallizable bodies, the latter of which is distinguished by the peculiar property of furnishing another base, *trimethylamine*, when mixed with soda-lime and subjected to dry distillation. Chemists have proved the presence of trimethylamine in the pickle of herrings. It is the cause of their peculiar odor. Urine contains it also in small quantities, hence its smell of herrings when much of it is evaporated down. The *belladonna* and the *datura strammonium* contain the alkaloid *atropine*, whose terribly poisonous properties are generally known, but which plays a very important part in treating diseases of the eye. Applied to the eye in a dilute state, or rubbed into the skin near the eye, it powerfully dilates the pupil and greatly facilitates certain operations on that organ. From all parts of the hemlock, a colorless, transparent oil of penetrating odor can be obtained, which is known under the name of *coniine*, and is one of the most poisonous alkaloids. Either this or *cicutine* contained in the water-hemlock was the cause of the tragical death of Socrates. In the St. Ignatius bean and the nux vomica, *strychnine* is found along with *brucine*; it forms a beautiful, crystallizable alkaloid, distinguished by its extremely bitter taste and by its producing tetanic spasms when injected into the blood.

To this class of organic bases belong also those poisons which savages use for steeping the points of their arrows. There are undoubtedly several such poisons. It seems that the one used by the savages of India and Africa is essentially different from that used by the natives in the northern part of South America. The former, called *antia*, immediately stops the beating of the heart, while the latter, called *curare*, first palsies the general muscular action and then stops the heart. *Curare* is the better known of the two; it was first brought to Europe by Sir Walter Raleigh in 1595. According to Humboldt, the preparation of this poison resembles our vintage feast. The savages collect poisonous vines in the forest, while the women prepare an intoxicating fermented liquor, of which they all partake. When all are intoxicated and lie in deep sleep, the master of the art prepares the poison by extracting the juice of the vines and evaporating it down. Different travelers agree that they also add poisonous ants and fangs of snakes. It would seem therefore that *curarin*, the active principle of the arrow-poison or curare, was a constituent of the juice of vines; but there is no certainty on this subject, since travelers do not agree in their accounts of the preparation of this interesting substance. Curare can be taken into the alimentary canal without the slightest danger, and even the meat of animals poisoned by it is innocuous, while it is certainly and often suddenly fatal when injected into the blood even in small quantity. When introduced into a wound, this poison occasions no pain whatever. The symptoms preceding death are very remarkable, as can be seen when a very small quantity is introduced into the blood of a large animal. There is an immediate relaxation of the muscles, all voluntary motion ceases, the animal sinks down powerless, but with its consciousness unimpaired, and finally the respiration ceases and death ensues, without the presence of any symptoms which would indicate excitement or a death-struggle. It is a progressive palsy, ending in the brain.

A whole series of organic bases is esteemed on account of the pleasant stimulating effect they exert on the body when in small quantities and diluted with other substances. They belong to the category of luxuries. Among them, *nicotine*, the active principle of tobacco, takes the foremost rank.

Pure nicotine is a liquid, which becomes brown in the light, has a tobacco-like smell and possesses very poisonous properties. The amount of nicotine contained in different kinds of tobacco varies. Although it is not exactly in the inverse, it is by no means in direct proportion to the excellence of the tobacco. Fine brands, such as Havana and Maryland tobaccos, contain but very little; the former not quite two and the latter from two to four per cent. Kentucky and Virginia brands contain as much as from six to seven per cent., and some of the domestic brands of Germany contain considerable quantities.

Besides nicotine, there are some other bitter principles contained in tobacco, which are the chief cause of nausea in young smokers. These are kept back by smoking pipes with long stems, which only allow the gaseous bodies to reach the mouth. Besides carbonic acid and carbonic oxide, tobacco smoke often contains as much as 3 per cent. of carbonate of ammonia, (which causes the increased secretion of saliva,) and also butyric acid, empyreumatic oils and resins, traces of sulphuretted hydrogen and even prussic acid, but no *creosote*.

Pepper owes its pungent taste to *piperine*, a crystallizable alkaloid. Tea and coffee both contain the same organic base, theine or caffeine, which are easily obtained from them in silky needles. A solution of this alkaloid neither has the taste nor the pleasant stimulating effect of an infusion of tea or coffee. In these beverages, as in tobacco, the value of the article used depends on other substances, which accompany the alkaloid.

Chocolate owes its value to *theobromine*, an alkaloid contained in cacao. It has been lately found that iodide of methyl digested with theobromine for some time in a sealed tube, at the temperature of boiling water, will convert it into theine.

The excellent effect of pure meat broth on the system is due to kreatine and kreatinine, two bases contained in meat. Broth, therefore, belongs to the same class as tea, coffee, and chocolate, and it certainly deserves the preference when the system of the sick person requires a stimulating and strengthening beverage.

Some organic bases have obtained a prominent place in the chemical arts. It is only necessary to mention *kyanole* or *aniline*, which is obtained in large quantities from coal-tar, and is used in the manufacture of the finest colors. Aniline red is the chloride or acetate of rosaniline, a colorless base obtained from aniline. Aniline violet must also be considered as an aniline base.

Two artificial bases, the amid bases of ethyl and methyl, which but lately had merely been preserved in chemical collections as interesting and rare substances, are now used instead of ammonia, in Carré's ice apparatus, in the artificial production of ice.

The description of the individual members of this extensive series of organic bases or alkaloids could be considerably extended if our time permitted, and if I did not fear to fatigue my hearers.

As I mentioned in my introduction, organic bases were a *terra incognita* to chemists half a century ago. As you probably have gleaned from my remarks, chemists have since diligently labored to explore this region; but whenever they had succeeded in scaling a height, from which they hoped to obtain a general view of what they had investigated, new and ever greater fields opened to their astonished eyes—fields whose exploration will require the most diligent efforts of chemists for many years.

Just as in the discovery of a new country the value of which the people realize only when the plowshare has turned the new soil and when its treasures have begun to circulate in the great commercial veins and arteries of the world, it happens with our organic bases, which are generally appreciated only as far as they are useful to commerce, the arts, or medicine.

Let us not forget, however, gentlemen, that as the treasures of the mountains of California and the products of India would never have enriched our country if it had not been for indefatigable travelers, who wandered through unknown countries, impelled by a pure love of knowledge. So we also owe our acquaintance with the organic bases to purely unselfish and scientific investigations, which have taught us that nothing is useless in science—a truth written in conspicuous letters on every page of the book of nature, and which can only fail to be read by the grossest ignorance.

THE NITROGEN BODIES OF MODERN CHEMISTRY.

A LECTURE BY PROFESSOR KLETZINSKY.

Delivered December 15, 1870.

[Translated from Aus der Natur for the Smithsonian Institution.]

I have the honor to direct your attention this morning to a group of compound bodies which are of the highest importance, whether we consider them from a theoretrical or a practical point of view. They are all the artificial products of the laboratory, and while the study of them has led to the most interesting views of the constitution of matter, some of them have found a widely-extended industrial application, and others give promise of a brilliant future. They are what is called the *nitrogen compounds* of modern chemistry:

Volume substitution is now accepted as the ruling principle of chemical combinations. All substances may be considered as combining in certain definite volumes, and the unit adopted by science in this respect is hydrogen. This atom, which in respect to weight and volume is the chemical standard, we denote as unity, and all other atoms which enter into the composition of bodies, and which require the same space as the atom of hydrogen, can be substituted in the place of this unit.

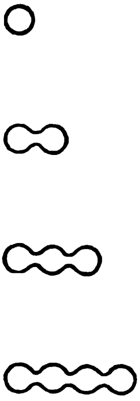
Chemists have succeeded in substituting for the hydrogen in organic substances radicals of hyponitric acid; that radical which is denoted by the formula NO_2.

This radical called *nitryl*, whose introduction into organic chemistry led to the conception of the nitrogen compounds, is formed when we unite one equivalent, of nitrogen having a combining power of 3 with the weight 14, and two atoms of oxygen which is bivalent, that is, having a combining power of 2 with the weight 16. This body is therefore represented by the formula $^{\prime\prime\prime}N^{\prime\prime}O_2$, in which the dashes ($^{\prime\prime\prime}$ $^{\prime\prime}$) represent the combining volumes. Since the nitrogen is trivalent and the oxygen bivalent, and since there are two atoms of oxygen the combining power of which is four, there evidently remains one unappropriated equivalent volume; and this free equivalent volume determines the equivalence of the radical. On this ground we designate this radical as univalent, or having a combining power of one; and as such it can be in all cases substituted for the hydrogen monad.

Now, if this substitution of nitryl for hydrogen in organic bodies be extended as far as the actual relations admit, we arrive at the formation of the nitrogen compounds. For a complete exposition of our subject we have still to mention the quadrivalent atom of carbon. The carbon atom requires four times the space of the hydrogen atom, and fills that space with the weight 12. It bears the symbol ''''C.

The elements, then, with which we have to deal and effect our exchanges are represented as follows:

Fig. 1.



1. Hydrogen, 'H.
2. Oxygen, ''O.
3. Nitrogen, '''N.
4. Carbon, ''''C.

The equivalence of the elements, *i. e.*, the proportion of their volumes compared with hydrogen as a standard, is not an invariable quantity. Expansion and contraction may take place in the atoms; within certain limits these can increase or decrease in volume. But it is important to observe that this expansion and contraction will always be bi-polar; that is, if a univalent atom expand it will do this in both directions and become, not bivalent, but necessarily trivalent. The trivalent nitrogen atom may become quinquivalent, but not quadrivalent. Hence, we have the simple rule that the character of the equivalence cannot change; if it is expressed by an even number it must still, though the atom contract or expand, be expressed by an even number; and reversely, if the equivalence is expressed by an odd number it must in all cases be so expressed. This will readily be understood if we suppose a unit volume to be added to each side of the symbol oxygen, carbon, and nitrogen, as given in Fig. 1. In this case the oxygen will become four, the nitrogen five, &c. The trivalent nitrogen atom in some circumstances may become quinquivalent. This expansion of atoms takes place when they are subjected to peculiar chemical actions.

I now call your attention to a salt which is produced from acetic acid and ammonia, and which is introduced into the pharmacopœia as the so-called spirit of Mindererus, the acetate of ammonia, or acetate of oxide of ammonium.

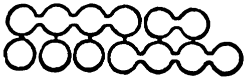
In the delineation of the formulæ of chemical compounds, without which a clear understanding of the processes is impossible, this acetate of ammonia is represented in Fig. 4:

It is necessary to state that in all acetic acid salts a radical called *acetyl* is common. This radical is represented as follows, in Fig. 2:

Fig. 2.

$$^{''''}C_2\ ^{'}H_3\ ^{''}O \longrightarrow$$

or



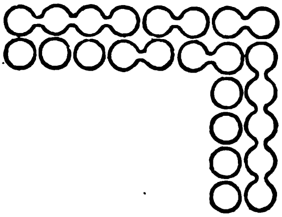
In order to form the salt from this radical we need a link of oxygen, which shall unite the radical of the base ammonium ($^{'''''}N\ ^{'}H_4$,) whose equivalence is one, there being four atoms of hydrogen and one of pentevalent of expanded nitrogen. This uniting oxygen is represented in Fig. 3.

Fig. 3.

Fig. 4.

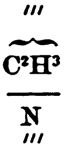
$$^{''''}C_2\ ^{'}H_3\ ^{''}O_1 + ^{''}O_1 + ^{'''''}N\ ^{'}H_4 = ^{''''}C_2\ ^{'}H_7\ ^{''}O_2\ ^{'''''}N_1.$$

or



The oxygen, which is here (Fig. 4) somewhat more distinctly marked, holds together the radical of the acid and the radical of the base, and thus forms acetate of the oxide of ammonium.

Now, when, by chemical agency, we force the water from this salt, as by a high degree of heat, by the action of chloride of phosphorus, or an anhydrous acid, (chemists have many expedients for separating water from organic compounds, forming it anew, and eliminating it again,) when, therefore, we take from this compound two molecules of water, 2 ($^{'}H_2\ ^{''}O$,) the nitrogen contracts from five to threefold equivalence, and we have the following formation:



$$\frac{\overset{'''}{\widetilde{C^2H^3}}}{\underset{'''}{N}}$$

Fig. 5.

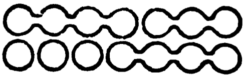
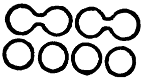


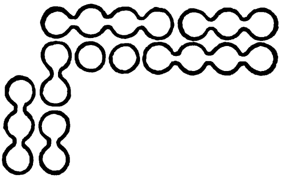
Fig. 6.



which represents the compound acetonitryl.

We obtain the same result if we saturate acetic acid with carbonate of ammonia; evaporate the liquid and distill the salt with chloride of phosphorus. The product thus obtained, the acetonitryl, furnishes a starting-point for further transformations. Suppose, now, that for one hydrogen atom we substitute the radical of unit equivalence, $(^{\prime\prime\prime}N\ ^{\prime\prime}O_2)$

Fig 7.



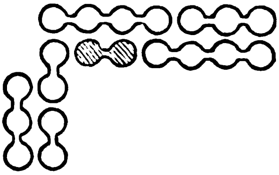
Here we have a perfectly-linked atomic-chain, where everything fits, a nitrogen body,

$$N^{\prime\prime\prime}\ C_2^{\prime\prime\prime\prime}\ H^{\prime}_2\ N^{\prime\prime\prime}\ O_2^{\prime\prime}$$

the nitro-acetonitryl.

If we substitute for the two remaining atoms of hydrogen one bivalent atom of mercury, (represented by the shaded circles in Fig. 8,) we shall obtain common fulminate of mercury.

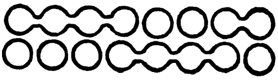
Fig. 8.



This latter substance cannot, in fact, be obtained from acetate of ammonia; our means are not yet adequate for that. We have another and quite different way, which is not less interesting; it is the action of nitrate of mercury on alcohol. When strong spirits of wine and strong nitric acid are mixed and metallic mercury is added to the mixture, in a short time nitrous acid vapor is developed, the mass begins as it were to seethe, and on cooling yields a deposit in the form of fine needle-crystals, and this is the fulminate of mercury.

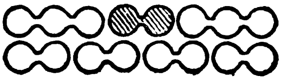
Alcohol has the radical so often occurring in chemistry, $C_2\ H_5$, and has the formula $C_2\ H_6\ O$, or

Fig. 9.



If nitryl mercury (represented in Fig. 10) acts upon this—

Fig. 10.



We shall have the compound represented in Fig. 11—

Fig. 11.

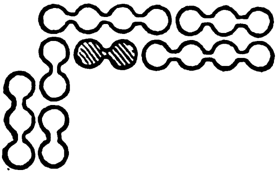


Fig. 12.

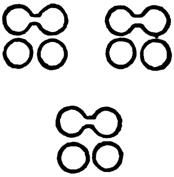
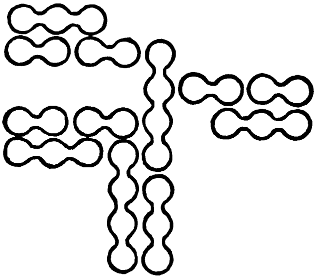


Fig. 12 represents the molecules of water extracted.

(In this again) we have fulminate of mercury and water. Finally, if in the above nitro-acetonitryl ($N''' C_2'''' H_2' N''' O_2''$) we substitute nitryl for the two hydrogen atoms, we obtain tri-nitro-acetonitryl—

Fig. 13.



a substance which forms crystals transparent as water, resembling naphthaline, and which on exposure to air emits a disagreeable odor, a body which liquifies at 45° and at 120° explodes with violence, rending its way through all obstacles. Now, whence arises this explosive force of the nitrogen bodies?

It comes in this wise: from the substitution of oxygen for hydrogen there occurs so intimate a blending of combustibles and supporters of combustion that on contact with a spark, on the signal given for decomposition, the whole mass with tempest swiftness, so to speak, burns up at once.

At the instant of combustion this solid substance is resolved into elastic fluids tending to expand, and, moreover, by reason of the augmented temperature attendant on the process of decomposition already expanded to a remarkable degree, and therefore filling a space many hundred times greater than before. If, by raising its temperature to 120° I should cause the decomposition of this body in the glass tube, in which, to prevent accidents, it is usually liquefied, there would result in place of this small quantity a volume hundreds of times larger than the tube; its cohesion being overcome, the glass would be shattered, and, with a report like that of fire-arms, the gas would escape into the air.

The effect of the common explosive gas depends on the intimate blending of the inflammatory oxygen with the combustible hydrogen.

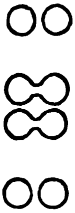
Liquids do not blend thus unless they are soluble in each other; unless they have a peculiar mutual affinity.

Oil and water placed in the same flask, and thoroughly shaken, will present a uniform appearance, but if left standing a short time they separate again, the oil gradually rising to the surface, and the heavier water sinking below.

The case is different with aeriform bodies. Two gases possessing no mutual affinity, if introduced into the same space, will each be diffused throughout the whole space precisely as if the other were not present, and the result will be their perfect uniform blending.

Suppose we admit into the flask two volumes of hydrogen and one of oxygen, the atoms will group themselves as follows:

Fig. 14.



H_2, O_2, H_2.

This, a million times repeated, affords an idea of detonating gas. The hydrogen is combustible, the oxygen is inflammatory, (the kindler,) there is needed only an electric spark, a glimmering splinter of wood, the presence of catalytic platinum sponge, or any other inconsiderable source of heat, and the hydrogen burns in the oxygen; an immense volume of watery vapor is suddenly produced, extremely elastic, at a temperature of 1000° R., and this forces its way through every obstacle.

Many nitrogen compounds act in accordance with this principle. By the introduction of nitryl, that radical abounding in oxygen, in the place of hydrogen, a more intimate combination of combustible and inflammatory substances is effected, even in solid bodies, than is possible in the most successful fabrication of gunpowder.

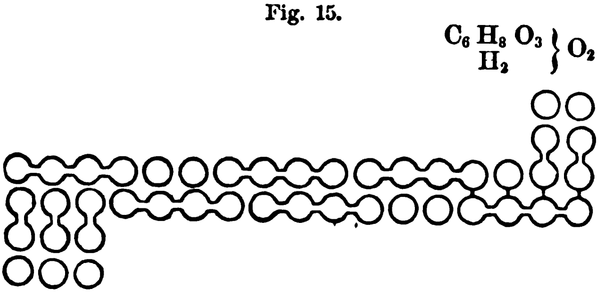
What is the operation of the manufacturer of gunpowder? He has two combustible substances, carbon and sulphur, and one inflammatory substance, saltpeter. Each of these three materials he reduces separately to the finest powder. He then mingles them, moistened, to avoid explosion through friction, and then with the utmost care rubs them together for hours, yes, days, till the blending is as intimate as it can possibly be made. He must still force the compound through sieves to grain it; he must smooth and glaze these grains, &c., but with the incorporation of these three ingredients his chemical labor is finished. Thus it consisted in producing the most uniform possible commixture of combustible and inflammatory substances, so that the carbon and sulphur, which are combustible, are throughout in contact with the saltpeter, which is the source of the oxygen. A spark coming in contact with a single grain the combustion is transferred from grain to grain, and the whole quantity of carbon and sulphur is consumed in the oxygen.

Nevertheless, gunpowder, though compounded with all possible care, though triturated and incorporated with the most scrupulous attention, can never acquire that perfect blending which may be attained by the introduction of combinations of atoms into the structure of organic formulæ.

As intimate and uniform an incorporation of the atoms as occurs in the nitrogen bodies can never be effected by the mechanism of powder-mills; and this alone indicates the importance of the nitrogen compounds.

Not among the earliest of those bodies, it is true, but a very recent descendant from them, and first brought into notice by the celebrated chemist Schönbein, is gun-cotton. Gun-cotton is ordinary cotton nitrogenized. Cotton is chemically called cellulose, vegetable cellulin, vegetable fibrin. Vegetable fibrin has the formula—

Fig. 15.



$$\left.\begin{matrix} C_6 H_8 O_3 \\ H_2 \end{matrix}\right\} O_2$$

In the middle we see the union of the carbon atoms to be firm; at the ends comparatively weak. Now if, step by step, we replace the hydrogen with nitrogen compounds, with nitryl, we have trinitrocellulose, wherein these atoms of hydrogen are replaced by nitryl, and we have before us gun-cotton, whose formation was effected by this substitution of nitryl radicals $N O_2$ for hydrogen.

The manufacture of gun-cotton is extremely simple. We require only the so-called nitro-sulphuric acid, which is in common use. There are two limits in compounding this acid. We may mix equal parts of good Nordhausen acid, or Saxon or Bohemian oil of vitriol, and of good fuming nitric acid, or three parts of Nordhausen acid and two parts of nitric acid; or two parts of Nordhausen acid and three of red fuming nitric acid. A mixture with either of these proportions produces a serviceable nitro-sulphuric acid, which has received the trivial name of fulminic acid from its use in the manufacture of fulminating compounds.

In mixing the brown oil of vitriol with red nitric acid there occurs a moment when the mixture of the two acids is nearly colorless. This is the state in which the compound is most available. It must be effectually cooled, if possible in a freezing mixture composed of three parts snow and one part epsom salts or common cooking-salt; or, at all events, in cold water, often changed; for the acid must be ice-cold to insure success. In this perfectly cold mixture immerse now, flake by flake, strand by strand, the cellulose, the pure vegetable fibrin. The purer the fibrin the drier and the freer from all mechanical soiling, the better of course will be the result. The cotton is immersed in the liquid by pressing it down with a glass rod; we wait till all the air-bubbles escape, till the cotton is fully saturated with the acid; moreover, we are careful to immerse no more cotton than can be contained without pressure and will be entirely covered by the acid. Half an hour, as I have repeatedly satisfied myself, is sufficient for the process; still there is no harm in leaving the cotton in the acid for an hour or several hours; thirty or forty minutes, however, are amply sufficient for the required effect. This done, with the glass rod take out the wet cotton, press it between thick plates of glass to remove the superfluous acid, throw it into an abundance of cold water to reduce the temperature, and immediately pick it apart, for if you let the compressed cotton fall into the water and lie there in a mass, you will find that, with a perceptible increase of temperature and the escape of reddish brown vapor, it gradually dissolves and disappears. After the cotton is thus pulled apart, and, as it were, drowned and quenched in cold water, it must be carefully washed, in a running stream if possible, for you will accomplish as much in six hours with running water, which easily penetrates among the fibers, as in two or three days with standing water. If all has been done as directed, you have first-class gun-cotton. It has now only to be dried, in a temperature not exceeding 100°, to expel all the water, and then it may be kept for years without the slighest deterioration.

We know what wonderful changes of opinion have taken place in our own time in respect to gun-cotton. The Austrian minister of war has really played with it the poetical game of the daisy: "Thou lovest me well, through good and ill, a little, or not at all." A large amount of money was expended on gun-cotton. At first, it was glorified; later, doubts were entertained; and then, when suddenly the tower of Simmering flew into the air, gun-cotton fell into disrepute. And yet England has recently made it the subject of a thorough investigation, and opinions in regard to it now seem very favorable. I have here some gun-cotton in the form of skeins and lamp-wick. This specimen is fully eleven years old, and in that time has not changed in the least, absolutely not in the least. It is just as effective to-day as when first made. It is a property of gun-cotton that in a moist condition, and notably when it has been imperfectly washed, it is decomposed in a way which may result in a partial dissolution and eventually in explosion. A spontaneous conbustion of clean, well washed and dried gun-cotton is inexplicable on scientific principles and is not known to have occurred. On being ignited gun-cotton explodes without smoke or vapor, and with no residue of ashes. We perceive only a weak odor of nitrous acid. It is a great advantage in the use of gun-cotton in blasting, that it does not leave that stifling atmosphere, that sulphurous smoke which renders approach impossible, as for example in mines. Particularly when common gunpowder is used for fracturing rocks, when experimental blastings are made with closed shafts, after the explosion the air is irrespirable, the ventilating shaft must act for a long time before the place can be entered. This inconvenience is avoided by the use of gun-cotton. I take this opportunity to indicate how we may easily and infallibly recognize a nitrogen body. It is merely necessary to produce its explosion in a partially closed space; the space becomes filled with weak nitrous acid vapor. For nitrous acid we have a very reliable reagent, the sulphate of iron. Of course the experiment should be made with a very small quantity of the cotton, as otherwise the explosion would be too violent; it would act in all directions, and prove its fracturing force on the vessel. I beg here to repeat that the explosion of such bodies consists in the sudden liberation of confined gases. There is an instantaneous production of gas occupying a hundred-fold the space of the cotton, a gas of high temperature and great elasticity. Such gases in a spherical space act in all directions; therefore they act not merely lengthwise of the tube but against the sides of it also. Now, if the action is on a scale not large enough to overcome the cohesion of the sides of the vessel, the gas has time to escape upwards; but if the action is so intense that its lateral components are sufficient to overcome the cohesion of the containing vessel, the fracturing force takes effect, the vessel is shattered. We must therefore use only a very small quantity in our experiment.

Nitrous acid changes the color of sulphate of iron to brown. We are not to expect a conspicuous change of color, observe, because most of the vapor escapes, only a small proportion remaining. Still there is enough to prove that we have to do with a nitrogen compound.

The slowly burning form of gun-cotton is called collodion-cotton. This modification of gun-cotton, which is not so rapidly consumed, but gradually burns out, is not used to propel projectiles, but it has other and very valuable uses. This allotropic form of gun-cotton is obtained by mixing English sulphuric acid with nitrate of potash and heating the mixture to 50°. The nitrate of potash is decomposed, and the result is bi-sulphate of potash and concentrated monohydrous nitric acid. When it is all dissolved we immerse in this liquid at 50° cotton well separated and dried, just as much as will lie in the liquid without pressure and be entirely covered, and we let it remain at this temperature, carefully watching it, from half an hour to an hour. The heat must rise no higher, for if it does the mass begins to develop red vapors, the cotton is in a tumult, and presently nothing is left but oxalic acid. The red vapor is a signal to lower the temperature. When this is all done the cotton must be picked apart, rinsed in cold water, and dried; and thus we have cotton which does not explode well, but which dissolves in alcohol and ether, while good gun-cotton will not so dissolve. Cotton prepared at freezing temperature is insoluble in alcohol and ether, or, at most, only slightly soluble in acetic ether. On the other hand, cotton prepared at a higher temperature, which explodes imperfectly, has just this property of dissolving in alcoholized ether.

In pure alcohol, entirely free from water and ether, collodion-cotton dissolves imperfectly or not at all. If the cotton be wet with pure alcohol the superfluous alcohol may be poured off and ether added; the cotton will now dissolve in common ether. The cotton wet with alcohol begins to dissolve in the ether, and the liquid thus obtained is usually filtered through cotton in its natural state to remove any fibers which may remain undissolved, and the filtered liquid is the so-called collodion, adhesive ether, *i. e.*, the solution of tri-nitrocelluline in alcoholized ether. This collodion may be saturated with gun-cotton to a somewhat thick liquid. Allowed to evaporate on glass, it leaves a film of collodion. This solution of collodion is applied to burns when there is no blood or moisture. In scalds, if not very severe, it does good service. In order to avoid painful contractions of the skin, it is best applied with a solution of castor-oil in alcohol. This imparts to it a degree of pliancy which causes it to yield to the motions of the skin without causing pain.

There is a whole series of bodies besides gun-cotton belonging to the same class; *e. g.*, nitro-mannite, obtained from mannite, from manna. If manna, such as is procured from the ash-tree, is dissolved in nitro-sulphuric acid, and left standing a while until red vapors appear, and then poured into cold water, a white, powdery, crystalline mass is precipitated; this is nitro-mannite. This substance explodes tolerably well. An attempt was made to substitute it for fulminate of mercury, but the attempt was abandoned. Nevertheless, it is destined to important uses in the industrial arts.

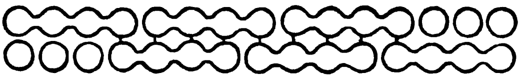
Ordinary cane-sugar treated in the same manner, dissolved in nitro-sulphuric acid, *i. e.*, a mixture of red fuming nitric acid and Nordhausen oil of vitriol, kept ice-cold, and when the red fumes appear, poured into cold water solidifies, and when it softens can be drawn into threads of almost silken luster. It is certain that the solutions of it in alcohol and ether, even in the water, in which it is preserved, taste extremely bitter. This body is called nitro-saccharine. By the mere substitution of nitryl for one atom of the hydrogen, the sweet taste of the sugar is changed to one thus intensely bitter. How complete a transformation takes place is shown by this, that nitro-saccharine is incapable of the vinous fermentation, is no longer a means of nourishment, but has become a poison, a foreign substance, which bids defiance to assimilation and digestion as well as fermentation.

When starch is treated in the same manner, the purest starch, from potatoes, rice, or wheat, when it is stirred into the mixture of acids, it cannot be said to dissolve, but a glutinous swelling takes place, and when on the appearance of the red vapor the mass is poured into cold water, a shining white substance is deposited, which is called xyloidine.

These are bodies less explosive, certainly, than gun-cotton, but which belong to the same class, carbo-hydrogens, in which the hydrogen is replaced by nitryl.

There are still other and very different nitrogen compounds, and, indeed, the first known, the oldest, belongs to a different chapter. This compound comes from phenyl acid, a radical which in many respects excites the interest of chemists. The main source of phenyl is benzol, $''''C_6\,'H_6$, or

Fig. 16.



Pure benzol is a colorless liquid, somewhat refractive, as evaporable as ether, of penetrating odor, but not unpleasant when much diluted. It is the well-known scouring drops. This most volatile of the coal-oils, called, eupion, is an exceedingly mobile and refractive medium, possessing the property of dissolving all oily substances without affecting any color or injuring any material; it can therefore be used to extract spots of grease and oil from all fabrics, even from the most delicate rose-colored silk. Spots from acids, fruits, or lye are not removed by it. It produces no effect whatever on discolored spots; it can merely remove the grease and with that the dust; for every spot of grease on a garment is naturally a place on which the dust floating in the air is deposited. This benzine or benzol is, in a scientific view, phenyl-hydrogen.

By replacing the hydrogen with hydroxyl, HO, we obtain from benzine carbolic acid, or phenyl acid, which in a pure state forms colorless crystals, but, however carefully protected from the air, it changes gradually to dull red, and finally to brown. Carbolic or phenyl acid is found in coal-tar, and is obtained from it in the form of carbolate of lime. The carbolate of natron, prepared by precipitating this salt of lime by means of a natron lye, is of inestimable value to the physicians as a means of obviating the fatal effects of hospital gangrene, of cleansing wounds, and exciting healthy action which has been suspended.

By substituting for one atom of the hydrogen in benzine—not hydroxyl, but nitryl—we obtain a new substance, nitrobenzol, mirbanol, and this brings us to ordinary perfumery. Thus, from the benzol of coal-tar is produced the artificial oil of bitter almonds, employed as a perfume in common pomades, in many cleaning mixtures, and substances containing strongly-scented mineral matter, and in common soaps. This mirbanol is obtained by mixing carefully, drop by drop, at a low temperature, benzol and nitric acid. It would be unsafe to mix at once the whole mass of benzol and nitric acid, since it would produce intense heat and lead to explosion. In mingling benzol and red fuming nitric acid there is need of the greatest foresight, carefulness, and subdivision of the process. In spite of refrigeration, the benzol dissolving in the nitric acid develops heat and gases, and when the masses have for a time acted on each other, they are poured into an abundance of cold water. Then, while the benzol, being lighter than water, floats on the surface, the mirbanol, which is heavier, sinks underneath; thus the nitrobenzol is prepared from the mixture of benzol with red fuming nitric acid. This crude mirbanol, which has still an unpleasant odor, is washed with weak carbonate of nitrogen, and then distilled off with extreme care. It is unsafe, after washing it, to place this compound in a retort over a fire, for, in case it approached the boiling temperature, there would be a flash, a fearful explosion, and the retort would be shattered. It must not be forgotten that, although this compound is not used for explosive purposes, it is a nitrogen body; you have admitted a wolf into the sheepfold; you have introduced the element of inflammability—oxygen—among the atoms of hydrogen, and when once the kindling takes place the hydrogen burns throughout the whole mass. And yet the crude mirbanol is distilled, because the consumption of it depends entirely on its freedom from color. This is accomplished by a chemical process, whereby the crude mirbanol is placed in a retort and the vapor of water introduced. At first, the water is condensed in the retort, but the vapor being constantly renewed, the water at length attains the boiling-point, is again vaporized, and escapes into the receiver at a temperature, however, below the boiling-point of mirbanol, and the latter is carried along by the watery vapor into the receiver. Of this device much use has been made, because this method of distillation at a low temperature greatly improves the odor and discharges the color of the substance distilled. I beg you not to suppose that the artificial mirbanol thus obtained from the crude nitrobenzol can be a substitute for the genuine oil of bitter almonds—a costly, natural ethereal oil. If you compare the two, you will find it absurd to give the same name to the former, so delicate and fresh is the genuine hydro-benzole, relatively to the crude and harsh nitrobenzol. They are indistinguishable, however, in a diluted state, and in alkaline fluids, particularly in lye compounds; in soaps the artificial oil is altogether preferable. Of these common products, for overcoming strong odors, the genuine, fine bitter-almond oil would be wasted—it would be lost—overpowered entirely by the rancid odor of the soap, for example, and would be less effective than its more powerful companion.

But this is not its only use. When mirbanol is exposed to hydrogen in a nascent state, a nitrogenous compound is formed, aniline, which is merely phenylamin:

$$C_6\ H_5\ N\ H_2$$

This is a substance whose synonyms bewilder the beginner in our science. Amidophenas, benzidam, krystalline, kyanol, aniline, phenylamin, they are all the same, but, singularly enough, their production was accompanied by wonderful misapprehensions. A chemist separating it from coal-tar, supposing it an oil, and observing that it gave a blue color to chloride of lime, called it kyanol, blue oil. Others have obtained it from phenyl acid, from the benzoate of ammonia; others again from indigo, and these called it aniline, from the Indian name of indigo, Anil Indigofera; no one suspected that all these different bodies, produced in different ways, were identical, until their composition was studied, and after numerous and varied experiments it was found that they were one and the same phenylamin. This base is obtained when we subject mirbanol to the action of iron filings. The mirbanol is placed in a covered kettle containing iron filings and water. The iron rusts; thus by attracting the oxygen, decomposing the water, and the nascent hydrogen from the decomposed water, produces aniline from the mirbanol. This process completed, the contents of the kettle are distilled, and crude aniline passes over. This requires repeated cleansing, and changes to manifold colors. Now, therefore, we find ourselves among the coloring substances.

When aniline and arsenic acid are subjected for some hours to intense heat, they are changed into a pitch-like, dark purple mass, which, on being purified, yields crystallized fuchsin; and if this red dye is dissolved in an excess of aniline and the solution heated again in the same manner, without suffering it to evaporate, it becomes a blue mass with a coppery luster, (azuline.) If we add nitric acid to rose aniline, we obtain aniline yellow and orange. If aniline is oxygenized with chromic acid, chloric acid, and the salts of copper, we have gray and black; if the sulphate of rose aniline is added to hyponitrite of natron, we obtain aniline green. There is scarcely a color of the spectrum or of art which cannot be produced from aniline.

Aniline is the root of innumerable shades of color, which are all of marvelous beauty, but extremely perishable, not subject to chemical influences, but whose chief enemy is the light; hence the exceeding tendency to fade, of fabrics dyed with aniline. For this reason they are suitable for those materials only which are soon worn out or soon out of fashion; while durable fabrics ought never to be dyed with these colors, since the light destroys them under all circumstances in a fabulously short time.

Aniline dyes have competitors. From the naphthaline of coal-tar—this coal-champion—have similar bodies been produced, and nitro-naphthaline furnishes a whole series of colors, which, however, are of no practical interest.

As the consumption of aniline dyes is enormous, efforts are now in progress to produce such modifications of them as will be soluble in water or diluted nitric acid; because the original solvent, alcohol, or wood-spirit, not only is too expensive, but also involves this evil, that constant inhalation of alcoholic vapor produces injurious, sometimes fatal, effects on those who are subjected to it.

When carbolic or phenic acid is mixed with fulminic acid, all three of the hydrogen atoms at the other extreme of the chain are replaced by nitryl, and thus is produced tri-nitrophenyl acid. This is probably the oldest of the nitrogen compounds, the all prevailing bitter, picric acid. This substance is of a pale-yellow color; by day a beautiful yellow, at night white. Picric acid dyes animal fabrics yellow, without the use of a mordant; it is almost poisonous, and particularly hostile to insects. It is proved by experience that animal fabrics impregnated with picric acid, with which we must always accept the yellow tint, are never attacked by moths or insects of any kind. When it is admissible, viz., when the color is not an objection and there is question merely of the preservation of the material, the use of picric acid may be warmly recommended. It is not so poisonous as to involve any danger in its use. Picric acid may be fixed in vegetable fabrics when these are impregnated with a solution of caseine in borax. Still the acid can never be made perfectly fast in these textures, while for animal fabrics it furnishes one of the most durable of yellow dyes. This acid was formerly obtained from different substances—from indigo, for example. Common Bengal indigo, evaporated with nitric acid, leaves a deposit, which on the application of heat decrepitates feebly. This is picric acid.

Aloes, which is unfortunately in so common use as a drastic purgative, digested with nitric acid also yields picric acid.

Recently the most abundant source of picric acid is gum acaroid, from an Australian tree, (*Xanthrœhoca hastilis.*) This resin, acted on by nitric acid, affords the highest percentage of picric acid. I must mention one more substance; and this is obtained by the action of nitrogen from glycerine, the so-called oleo-saccharum, a widely-diffused article, which has the formula:

$$C_3\ H_5\ H_3\ O_3$$

We may suppose it a three-fold water, in which three atoms of hydrogen are replaced by the bivalent radical glyceryl,

$$\widetilde{C\ H_5}$$

We can substitute nitryl for three atoms of the hydrogen in the glycerine and then we have trinitroglycerine, glonoïn, or glonoïdin, the Swedish explosive oil, a body first produced and examined by Sobrero, and which is heavier than water, (1.06.) To prepare this we add a deciliter of the purest glycerine, free from water, to Nordhausen sulphuric acid and red fuming nitric acid, mixed in the proportions of 6:4; thus, *e. g.*, one liter to 600 cubic centimeters and 400 cubic centimeters, which mixture must be kept ice-cold; it should stand in the cold several hours. Then this liter is poured into at least ten liters of ice-cold water, and the heavy, colorless oil, trinitroglycerine, sinks to the bottom; it should be well washed in water, in which it is nearly insoluble. In watery alcohol it dissolves with difficulty, but readily in absolute alcohol, ether, and pyroxylic spirit. It has a sweet but unpleasant taste, and induces protracted headache, so that the homœopathists have seized upon it as a specific against headache. This Swedish explosive oil is apparently the most formidable of the nitrogen bodies; while one gram of gunpowder affords 300 cubic centimeters of gas, one gram of nitro-glycerine developes 720 cubic centimeters. Moreover, the gunpowder leaves, theoretically, 43 per cent. of residuum, while nitro-glycerine leaves none at all, for the large proportion of oxygen is so perfect a kindler for the mass that it is changed altogèther into gas. This gas contains 58 per cent. carbonic acid, 20 per cent. watery vapor, 3½ per cent. oxygen, 18½ per cent. nitrogen.

Oxygen is seldom observed among the gases resulting from explosion, and I do not think the oxygen found in this case is free; it is probably present as nitroxyd gas, and still a compound which supports combustion. The tremendous force of nitro glycerine renders it the most energetic servant in our mines, it divides our rocks, does all the work of blasting, it is the Polyphemus of modern civilization—goes parallel with fearful accidents. The slightest imprudence may provoke a terrible reaction; and, moreover, it is a very capricious substance, which does not explode as readily as gunpowder or gun-cotton; occasionally it burns away quietly; on this account, ignorant people who have to do with it grow more and more fearless, more and more careless, they disregard the warnings of their overseers until at length they become foolhardy and do something which arouses it from its indifference, when it explodes, rending and destroying everything in its vicinity. The fact that the liquid state of nitro-glycerine causes it to leak and spread everywhere led to attempts to produce it in a solid form, and the result of these attempts is dynamite. This is merely a combination of nitro-glycerine with siliceous earth, containing a small quantity of oxide of iron, which tinges it yellow. This siliceous earth is the product of algæ of infusoria, and of microphytes, and has a peculiar tubular structure. The tubules, by reason of their capillarity, absorb the nitro-glycerine, and hold it so firmly that it never becomes moist nor does it yield to light pressure or friction; therefore this form, dynamite, is comparatively harmless, and has in some degree superseded the formidable explosive oil. Dynamite explodes at 180°. An explosion in unconfined space is very different from one that takes place under pressure. If I burn gun-cotton in the open air the explosion is attended by no remarkable effect, because the air-waves equalize and convey away the shock; but in a confined space the explosion exerts its fracturing force on whatever is nearest. This, of course, holds good of dynamite, and hence the numerous accidents resulting from careless handling of the charges—I might say from the utterly reckless use of dynamite. At first the untaught laborer is cowardly, too careful and fearful, when warned of danger by the experienced overseer; by degrees he grows less vigilant, he begins to imagine that the matter is not quite so serious, and finally, in some way, arouses this malicious substance, and then the catastrophe takes place.

It is to be hoped that this explosive compound will be in all cases manufactured at the place where it is to be used. The production of it is so easy, success is so certain, that I do not comprehend why the hazard of its transportation and the innumerable consequent accidents should be encountered.

It is possible that this dangerous, untamed laborer, who performs the compulsory service of cleaving our rocks and mountains, will yet become civilized; it may be that, through progress in mechanics, in chemistry, and in general science, it will become possible to subdivide and control the explosion, and to use it, thus controlled and modified, as the most convenient source of power to move our pistons and propel our machinery.

SCHEME FOR THE QUALITATIVE DETERMINATION OF SUBSTANCES BY THE BLOW-PIPE.

By T. Egleston, E. M.

In the course of my instruction in blow-pipe analysis, I formerly found great difficulty in teaching the students how to distinguish with certainty, and within a limited time, the substances contained in a mixture of four or five ingredients. The old routine method of examination in the closed and open tube, and then on charcoal, &c., answered very well when not more than one or two substances were present, but did not answer in the hands of beginners when they came to examine alloys. For a long time I was convinced that it was useless to expect of a student that he should be able, without extended practice, to determine, qualitatively, the composition of a very complex substance. It finally suggested itself to me, however, that a plan similar in some respects to the one used in certain quantitative assays would answer for the general outline of qualitative work. I therefore prepared a provisional scheme, which, in order to test, I gave to the students to work with. The result of a few weeks' use of this scheme convinced me that it was possible so to arrange one as to make it applicable to almost any compound, whether it was natural or artificial. I therefore drew up a carefully-prepared scheme, which was modified from time to time, as changes were suggested by its use in the blow-pipe laboratory. The result was such that I felt no hesitancy in giving to students who had had only a few weeks' practice, complex mixtures, feeling certain that they would work systematically, and consequently with confidence and pleasure, where they were formerly in doubt. This scheme has been in constant use for four years, and has effected an entire revolution in the working of the blow-pipe laboratory. Much of the success which has attended its use is owing to the publication of a translation of Plattner's Manual of Blow-pipe Analysis, by Professor Cornwall,* to which constant reference is made in the scheme. I have to acknowledge in its preparation the valuable suggestions of my two former assistants, Mr. J. H. Caswell and Professor H. B. Cornwall.

With regard to the use of the scheme, the routine to be followed may be varied according to circumstances. If sulphides, arsenides, &c., are being treated, the substances must be carefully roasted. If test 1 fails to show As, Sb, S, or Se, as sulphides, &c., the substance is either an oxide or an alloy. If it is an oxide, the roasting, 2, is omitted. If it is an alloy, it is subjected to the test 1, *a*, for Pb, &c., and then the test 2 **A** is performed by fusing it on coal with borax in the R. F., thus combining 2 **A** and 2 **A** *a* in one operation. Some sulphides during the roasting, 2 **A**, will become reduced to the metallic state, and then, after thorough roasting, may be treated as alloys. A metal, or a raw sulphide, &c., must never be treated on platinum wire, but the metal is fused on coal, with a flux. This is done in R. F. if it is desired to get only non-reducible metals in the flux, such as Fe, Co, &c. If Cu, Ni, and other reducible metals are to be fluxed, it is performed in the O. F. The *flux* so prepared is then transferred to the wire. Sulphides, etc., must always be roasted before testing with borax, or S. Ph.

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*Plattner's Manual of Qualitative and Quantitative Analyses with the Blow-Pipe. Translated by Professor Cornwall. 2d edition, D. Van Nostrand, New York, 1873.

The word *bead* always refers to the flux, and *button* to the metal. In regard to 2 **B**, Sn and Zn are rarely found together, except in alloys. The presence of the one generally implies the absence of the other. If they are together as oxides, Sn can, however, always be found in the presence Zn by reducing them with soda and a little borax, and triturating the mass with water, p. 90.* In alloys the Zn can be detected by treating for a short time in the R. F.; the Zn, if present, will volatilize first, and the coating may be tested with the cobalt solution.

SCHEME.

The substance may contain **As—Sb—S—Se—Fe—Mn—Cu—Co—Ni—Pb—Bi—Ag—Au—Hg—Zn—Cd—Sn—Cl—Br—I—**$\mathbf{Co^2}$**—**$\ddot{\mathbf{Si}}$**—**$\overset{\cdot\cdot\cdot\cdot\cdot}{\mathbf{N}}$**—**$\dot{\mathbf{H}}$, &c.

1. Treat on Ch. in the O. F. to find volatile substances such as **As—Sb—S—Se—Pb—Bi—Cd.**, &c., p. 66 *et seq.* Test in an open tube to see whether As, Sb, S, are present as arsenides, &c., or in an oxidized state, p. 63 *et seq.*

a. If there are volatile substances present, form a coating, and test it with S. Ph. and tin on Ch. for **Sb**, p. 99, or to distinguish between **Pb** and **Bi**, p. 280.

a. Yellow coat, yielding with S. Ph. a black bead; disappearing with blue flame, no part of it yielding greenish Sb flame. **Pb** and **Bi.**

b. Yellow coat, generally with white border, yielding black or gray bead with S. Ph, disappearing with blue flame; also the border disappearing with green flame; **Pb** and **Sb.**

c. Yellow coat. very similar to *b*, but yielding no blue flame; **Bi** and **Sb.**

d. Make a special test for Bi, p. 521. Pb in presence of Bi, if not in too small a quantity, is detected by the blue flame yielded by the coat, or by the reduced metal itself, p. 521.

b. If there are no volatile substances present, divide a part of the substance into three portions, and proceed as in **A.**

2. If **As—Sb—S—Se** are present, roast a large quantity thoroughly on Ch., p. 77. Divide the substance into three portions, and proceed as in **A.** P. xv, note.

A. TREATMENT OF THE FIRST PORTION.—Dissolve a very small quantity in borax on platinum wire in the O. F., and observe the color produced. Various colors will be formed by the combination of the oxides. Saturate the bead and shake it off into the porcelain dish; repeat this once or twice, p. 79.

a. Treat these beads on Ch. with a small piece of lead, silver, or gold, in a strong R. F., p. 113.

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* These numbers refer to the pages of Plattner's Manual, translated by H. B. Cornwall, 2d edition. D. Van Nostrand, New York, 1873.

b. **Fe—Mn—Co—&c.,** remain in the bead, p. 115.

If the bead spreads out on the Ch, it must be collected to a globule by continued blowing. Make a borax bead on platinum wire, and dissolve in it *some* of the fragments of the bead, reserving the rest for accidents.

c. **Ni—Cu—Ag—Au—Sn—Pb—Bi** are reduced and collected by the lead button. Sn, Pb, Bi, if present, will be partly volatilized, p. 115.

Remove the lead button from the bead while hot, or by breaking the latter, when cold, on the anvil between paper, carefully preserving all the fragments.

d. If **Co** is present, the bead will be blue.

If a large amount of **Fe** is present, add a little borax to prove the presence or absence of **Co,** p. 222.

If **Mn** is present, the bead, when treated on platinum wire in the O. F., will become dark violet or black.

e. If only Fe and Mn with no **Co** are present, the bead will be almost colorless.

Look here for **Cr, Ti, Mo, U, W, V, Ta** by the wet way.

A considerable amount of Ti may be detected with S. Ph, and tin in the original oxides, in absence of other non-reducible coloring oxides, p. 323. Mo will be shown by the cloudy brown or black appearance of the borax bead in the R. F. on platinum wire, p. 105.

f. Treat the button *c* on Ch, in the O. F. until all the lead, &c. is driven off; **Ni, Cu, Ag, Au** remaining behind; or separate the lead with boracic acid, p. 442.

g. Treat the residue *g* on Ch, in O. F. with S. Ph bead, removing the button while the bead is hot.

h. If **Ni** and **Cu** are present, the bead will be green when cold, p. 292. If **Ni** only, yellow. If **Cu** only, blue.

Prove **Cu** by treating with tin on Ch in the R. F., p. 293.

i. For **Ag** and **Au** make the special test No. 8.

B. TREATMENT OF THE SECOND PORTION.—Drive off the volatile substances in the O. F. on Ch. Treat with the R. F., or mix with soda, and then treat with the R. F., for **Zn, Cd, Sn.** If a white coating is formed, test with cobalt solution, pp. 251, 256, 276. Note, p. XV.

C. TREATMENT OF THE THIRD PORTION.—Dissolve some of the substance in S. Ph on platinum wire in O. F., observing whether Si O^2 is present or not, and test for **Mn** with nitrate of potassa, p. 210.

3. Test for **As** with soda on Ch, in the R. F., or with *dry* soda in a closed tube, p. 345 *et seq.*

4. Dissolve in S. Ph on platinum wire in the O. F., (if the substance is not metallic and does not contain any **S.,**) and test for **Sb** on Ch with tin in the R. F., p. 99. To detect small amounts of Sb with Cu or Sn, see p. 331.

5. Test for **Se** on Ch, p. 368.

6. In absence of **Se** fuse with soda in the R. F., and test for **S** on silver foil, p. 365. In presence of **Se,** test for **S** in open tube, p. 366. To distinguish between S and SO^3, see p. 368.

7. Test for **Hg** with *dry* soda in a closed tube, p. 304.

8. Mix some of the substance with assay lead and borax glass, and fuse on Ch in the R. F., p. 401. Cupel the lead button for **Ag.,** p. 407. Test with nitric acid for **Au,** p. 320.

9. Test for **Cl, Br,** and **I** with a bead of S. Ph saturated with oxide of copper, pp. 373, 374, 375.

10. Test for **Cl** or **Br** with bisulphate of potassa, p. 374.

11. Test for **HO** in a closed tube, p. 353.

12. Test on platinum wire, or in platinum pointed forceps, for coloration of the flame, p. 72 *et seq.*

13. Test for $\mathbf{CO^2}$ with hydrochloric acid, p. 360.

14. Test for $\mathbf{NO^5}$ with bisulphate of potassa, p. 354.

15. Test for **Te** in an open tube, p. 351.

BLOW-PIPE APPARATUS,

MANUFACTURED BY HAWKINS AND WALE, STEVENS INSTITUTE, HOBOKEN, NEW JERSEY.

FOR QUALITATIVE DETERMINATIONS.

Blow-pipe, with two platinum jets	$3	00
Extra jets, each 75 cents		
Blow-pipe lamp	4	50
Platinum-pointed forceps	1	75
Brass forceps		75
Steel forceps, for lamp		22
Cutting plyers	1	50
Platinum wire-holder, with six wires	1	50
Hammer		75
Anvil		65
Bar-magnet		35
Magnifier, with two lenses	1	25
Alcohol lamp, with brass cover		75
Charcoal saw		35
Knife		38
Two brushes		26
Lamp-scissors		40
Coal-tray		65
Dirt-tray		40
Charcoal-borer, club-shape	1	25
Steel mixing-spatula		40
	21	06

FOR QUANTITATIVE DETERMINATIONS.

Holder for evaporating-dish, triangle, &c	$2	00
Holder for funnel and chimney	1	54
Flat-nose plyers, (nippers)		45
Charcoal-borer, four cornered		62
Charcoal-borer, with spatula		40
Two ivory spoons		60
Mattrass-holder		35
Mixing-capsule, brass gilded		45
Two brushes		26
Box for soda papers		23
Wooden form for paper cylinders		15
Cupel-holder, with two cupel-cups and one mold	1	75
Charcoal-holder, with platinum ring and screen	2	25
Test lead measure		38
Assay button brush		45
Stand for charcoal-holder		12
Charcoal-borer, club shape	1	25
	13	25

THE BOUNDARY-LINE BETWEEN GEOLOGY AND HISTORY.

A LECTURE DELIVERED BEFORE THE VIENNA SOCIETY FOR THE DIFFUSION OF SCIENTIFIC KNOWLEDGE,

BY EDWARD SUESS.

[Translated for the Smithsonian Institution.]

If we were to attempt a general review of the whole past history of our earth and its inhabitants, we should be immediately led to consider the first appearance of man as one of its chief epochs. The study of the countless ages preceding that epoch belongs exclusively to geology and palæontology; the study of the later and much shorter period principally to history.

The boundary between geology and history is therefore the time of the first appearance of man, and it is the part of a lecturer on this epoch to describe the phenomena which attended the first appearance of the human race. However, that cannot be done in the present state of science, since it is probable that man did not appear everywhere at the same time. Perhaps thousands of years intervened between his first appearance in Asia and America, in Europe and in Australia, and hence it is necessary to divide our subject into geographical periods. We shall confine ourselves to *the first appearance of man in Central Europe*, that part of the earth being the only one which has been sufficiently investigated in this respect to arrive at any possible scientific conclusions.

Geology teaches that our mountains were produced by numerous disturbances after many changes in the distribution of land and water, and that afterward they assumed their present forms, and the continents their present outlines. Palæontology exhibits to us strange beings in the first periods of life, whose forms, only in a few instances, present any analogy to existing species. The nearer we approach the present time, however, the greater becomes the similarity to the present animals and plants. Even before the appearance of man in Central Europe, there were first marine and then land animals and plants, kindred to which still exist; and since their places and modes of living are known, we are enabled to draw from them many certain conclusions as to the external conditions of life in those ancient times. In this way the geologist and the palæontologist approach the first appearance of man from distant ages, and the nearer they approach the clearer are their observations and the more certain their conclusions. The opposite is the case in history; the historian must go backward to arrive at the same point.

If, now, in Middle and Northern Europe we endeavor to go back before the times of which we have the short and partial descriptions of

Roman historians, we find nothing but a few obscure traditions. It is known, however, especially through the examination of ancient graves, that these regions were inhabited by people who made their weapons and tools of bronze, a mixture of copper and tin. The remnants left by these people indicate peculiar taste for ornaments and great skill in the working of these metals. This great epoch of civilization is called the *age of bronze.*

Other discoveries show that before the age of bronze there lived a people who were ignorant of the manner of working the metals. They made their weapons and utensils only of stone, sharp splinters of bones, and of wood. This more ancient epoch has been called the *age of stone.* To it belongs a great number of the graves found in Denmark and Sweden. Our knowledge of the mode of life of some of these ancient peoples has been increased in an unexpected manner by the discoveries of the Swiss archæologists. The very low water-mark to which the Swiss lakes fell in 1854 laid bare extensive palafittes or pile-constructions in the lakes of Geneva, Constance, and many others. In some of these, remnants of the age of bronze, and in others of the age of stone, were found between the piles in the muddy bottom of the lakes. On these piles were erected formerly the habitations of the natives in such a manner as to protect them against the attacks of their enemies and of wild beasts. It is known that such palafittes are still in use in New Guinea; and Herodotus gives a detailed description of similar constructions in Lake Prasias, where Megabazus, the general of Darius, found them.

Apparently the age of stone can be divided into an earlier one, in which men only knew how to cleave stones in order to give them the required shape, and a more recent one, in which they understood the art of grinding and polishing stone articles. The traces of the oldest time are the most interesting, because we can inquire how far they correspond with the facts which natural science reveals to us. Here, then, geology and palæontology have their brightest pages, while history shows us the first traces of human existence. For this reason our consideration of the question is geological rather than archæological. Our method will be as follows: First, we shall consider the phenomena apparent in the inorganic creation of that epoch, and then describe the plants and animals which existed in these regions immediately before the appearance of man. We shall also show under what circumstances traces of the oldest age of stone have been in various places discovered.

There are in these places large masses of loose rocks, which evidently came into their present position at a time after the surrounding country had assumed its present condition. The most remarkable of these are those brought to their present places by the glaciers. Ice is not absolutely solid, but possesses a certain degree of viscosity, which causes masses of it collected on the high mountains to flow slowly down into the valleys in the form of great streams of ice. These would soon fill up the valleys were it not for the milder temperature of the latter, which melts them and puts an end to their progress. Frequently rocks fall down upon them from the precipices above and are carried down into the valley. These stones collect at the lower end of the glaciers, forming heaps called moraines, and are usually in the shape of a half-moon with its concave side toward the glacier. If a long-continued cold temperature sets in, which favors the progress of the glacier, the latter will push before it the moraine, along with a mound of earth, uprooted trees, &c.; and if the temperature rises, the lower end of the glacier melts away and the glacier apparently recedes, leaving the moraine at its advanced position as a mark of its extent to future observers.

Such advanced moraines are found with nearly all the larger groups of glaciers in Central Europe, some of them miles away from the present end of the glacier, as, for instance, at Berne and Zurich in Switzerland. Mountain-ridges like the Carpathian, which have no ice near them to-day, have ancient moraines. Marienzell rests upon bowlders brought to their present position by glaciers. At the foot of the Rosalia Mountains are found the traces of glaciers which formerly existed on the Wechsel and Schnee Mountains.

Since these moraines extend directly across the valleys, they often obstruct the water-courses and give rise to Alpine lakes. The upper lake of Gosau is bounded toward the valley by the moraine of the western Dachstein glacier. The "Meerauge," a lake in the Tatra Mountains, is hemmed in by a similar moraine, although at the present time there is neither a glacier nor even an extensive snow-field in the place. All these moraines are a proof that a much colder temperature must have prevailed in these regions at a time after they possessed their present formation, and if these traces of past glaciers are so numerous in the latitude of Switzerland, we can easily imagine that they are still more extensive farther north, in Scandinavia.

The northern part of Europe also presents other striking phenomena, which must be described in detail. The topography of a region depends on the relative height of its different parts; the distribution of land and water on the absolute height of the whole. The level of the sea may be taken as unchanged. By the "continental" elevation and depression of large regions, considerable changes have been produced in the outlines of the dry lands, and these changes are divided into three great epochs.

1. The first epoch is that of depression. Then the sea extended as far as Hanover, and from Breslau to Cracow. The whole North German and Central Russian lowlands were under water. Scandinavia and parts of the British Isles were above the surface of the sea. In Scandinavia the ends of the glaciers reached down into the sea, just as they do in arctic regions in the present day, and from time to time a large piece, often covered with huge blocks of the moraine, would separate, float down to the southward, and there deposit its load. Thus it hap-

pens that a large portion of Central Europe is to-day covered with a bowlder formation of Scandinavian or Finnic origin.

2. The following epoch is, on the contrary, one of extensive and considerable upheaval or elevation, which has been specially studied by the English geologist Austin. While the sea had before extended so far into Central Europe, all the sea-bottom between Ireland, France, England, and Scandinavia was now raised above the surface of the water, and our continent extended as far as the Shetland Islands. What is to-day the North Sea was then an extensive lowland, traversed, no doubt, by a large stream, the continuation of the present Rhine, which then had the Elbe and the Thames for tributaries, and its mouth far to the northward. Even at the present day fishers find in the deeper portions of the North Sea bones of deer and elephants, which once lived on the banks of that great river. On many portions of its banks submerged forests are known to exist, reaching far below the present sea. The present bottom of the sea presents a line of steep descent at a depth of about 200 fathoms. This line runs west of Scotland and of Ireland, including, therefore, that island also, and approaches the present continent only in the direction of the Bay of Biscay. There is some reason for supposing that this line indicates the former outlines of Europe.

3. The next epoch was that of the depression, which gave the continent of Europe its present form.

The most important changes which can be recognized in Europe at so late a period are a severer climate and repeated alterations in the distribution of water and land. Astonishing as these phenomena may appear, a glance at the present state of things will demonstrate their possibility.

Europe possesses at present an exceptionally mild climate; a stream of warm water coming from the Gulf of Mexico washes and warms the greater part of its western coast; warm currents of air blow over its southern parts from the Desert of Sahara, and the absence of a large extent of country near the north pole prevents the accumulation of great masses of snow, and the cold winds resulting from it. But all these favorable conditions could be completely removed by a change in the distribution of land and water. Such changes are, indeed, still going on in some places. A portion of Sweden is known to be rising, while a part of Greenland is sinking with considerable rapidity.

Having thus far considered only the inorganic world, let us now turn our attention to the organized beings which inhabit Central Europe under the above circumstances, and we will see that their character entirely corresponds to a severer climate.

The remains of the land-animals of those times are found either in alluvium or in caves. An alluvium of yellowish-brown clay, found in most river-valleys of Central Europe, is formed by fresh-water rivers or lakes, and contains no sea-shells. In it we find the shells of various land-snails and the remains of herbivorous mammals much more frequently than those of beasts of prey. In caverns, however, the latter predominate. Since the herbivorous animals, which were carried to the caverns by beasts of prey, were the same as those found in the alluvium, and since we occasionally find remains of the same beasts of prey in the alluvium, we are justified in considering their existence as coeval. The whole fauna of mammals may be divided into four groups:

1. Animals now extinct and not mentioned in human traditions. To these belong the mammoth (*Elephas primigenius*), the large two-horned rhinoceros with bony septum in its nose (*Rhinoceros tichorhinus*), the cave-lion, hyena, and bear, and the *Ursus priscus.*

2. Animals which are known to have become extinct, or to have been exterminated in historical times. Among these are the "schelch" of Niebelungen-Lied, (*Cervus euryceros* Aldr.,) a very large species of deer, related to the fallow-deer, but much larger; the *Urus*, or ur, of the ancient Germans; and another species of ox, the *Bos longifrons.* Among those which are nearly exterminated or driven out of Central Europe in historical times are the wisent of the Niebelungen-Lied—an animal still kept in the Lithuanian forests by order of the Russian government, and often exhibited as a *Urus* in menageries—the elk, and the beaver.

3. Animals still living in Central Europe, such as the wolf, fox, pole-cat, hog, horse.

4. Animals still extant, but not in the lowlands of Central Europe. To these belong the reindeer, the North American musk-ox, the common lemming, the glutton, (wolverine,) which now live much farther north, and the marmot, now found on the Alps.

The fourth group of mammals points with great certainty to a colder climate during those times. The bones of all the above-named animals have either been found in the alluvium, or in caverns, or in both. But besides these direct discoveries, there is an indirect way of obtaining information concerning the ancient flora and fauna, which the English naturalist, Edward Forbes, has the credit of discovering. The phenomena which will now be mentioned seem better calculated than all others to cast some light on the first appearance of man in Central Europe.

The researches of the last decade leave no doubt that each species of animal or plant had an original home, from which it spread in different directions in the course of time, according as the external conditions of life permitted, and no geographical obstacles, such as a sea, or a very high mountain-chain in the case of a land-animal, were in the way. Hence, each species has a geographically connected region; and where this is not the case, we may assume that this region was divided by later influences.

In many cases human influence is perceptible; the lion, for instance, has a considerably divided region, having been exterminated in the ancient civilized countries. The ox, on the contrary, has a twofold home, by having been transported to America.

All these changes produced by man affect only single species, and not the whole fauna. The phenomena which must be ascribed to geological revolutions are much grander. The flora of the Canary Islands and of the Azores, in particular, shows so great a resemblance to that of the Western European coasts, that we must assume the former connection of these points in spite of their present distance apart. The inhabitants of the island of Madagascar differ, on the other hand, from those of the eastern coasts of Africa, and those of the Galapagos Islands from those of the coasts of South America. Hence it follows either that the separation of these islands from the continent is older than the inhabitants of the islands, or older than those of the continent, or older than either.

In Central Europe there are to-day two remarkable examples of divided regions. The first consists in the identity of the fish species in our various rivers, and this is at least partially explained, on geological grounds, by the very plausible supposition of a large stream in the region of the present North Sea, which had the Thames, the Elbe, and others for tributaries. The present inhabitants of our rivers may be considered as the isolated remains of those which formerly peopled the great united stream.

The second phenomenon is the following: On the isolated heights of various mountains a peculiar flora repeats itself, and many species of this Alpine flora are found again far away in Scandinavia and Lapland. Many animal species are distributed in the same way. The white mountain-hare, (*Lepus variabilis*,) for instance, is found in the pine-districts of the Alps, on the mountains of Scotland and Ireland, and in Scandinavia, Lapland, Northern Russia, Siberia, and Greenland. If this animal came on our mountains from the far north, how does it happen that it is not found in the intervening valleys?

Now if the hypothesis of the original connection of such regions is correct, these Alpine species must have had some connection with the northern ones; and since it has been observed that the reindeer and lemming not always lived far north, but also in Central Europe, and that the marmot could also exist there, it is highly probable that in Central Europe all those species of plants and animals existed then which are now found both on our mountains and on those in the north.

In the colder time these beings, therefore, had their common abode in Central Europe, and were distributed gradually while the change of temperature was going on, since they could only find the conditions necessary to their existence on high mountains or in boreal countries. Some only remained in the valleys, (those of the second and third groups,) some became extinct, (those of the first group,) and some emigrated, (those of the fourth group.) At the same time new species of animals and plants appeared, which form the greater part of those of the present day. The merit of having indicated how we may obtain information on the order of their appearance also belongs to Edward Forbes.

The gradual appearance of these species is connected with the establishment of a milder climate, a consequence of the great depression or sinking of the European coasts, through which the sea gradually encroached on the Rhine, forming the North Sea and also St. George's Channel. With the immigration of new species the British Islands gradually separated from the continent, and this isolation had been already accomplished before the new-comers had spread. These found insuperable obstacles in the newly formed channels, and never reached Great Britain. Hence it comes that of the twenty-two species of reptiles existing in Belgium, only eleven are found in England, and only five in Ireland.

According to Mr. Thompson, if we compare the Irish fauna with the English, we will find that the former is deficient in many instances. Ireland lacks fourteen or fifteen species of the eighteen English varieties of bats, many other common animals, as the squirrel, the dormouse, all field-mice without exception, the common field-hare, the pole-cat, the wild cat, the mole, many kinds of shrew-mice, all snakes, the common lizard, (*Lacerta agilis,*) &c. All these, we may therefore suppose, reached England only after Ireland had separated. Hence we see why the mountain-hare is found on the Irish mountains, while the common field-hare is wanting in the valleys. It also appears that some of the most common inhabitants of our fields and meadows are among the animals wanting in Ireland. Perhaps the country was composed only of forests and swamps at the time Ireland became separate.

We furthermore see that the animals now existing together in Central Europe did not appear together; they may, therefore, be divided into groups, not according to their organization as by the systematist, but simply according to the date of their appearance in Central Europe.

It is from this point of view that we may obtain the means of judging of the first appearance of man in these regions. We must show under what circumstances the most ancient traces of man were found. Two instructive and fully accredited discoveries will suffice to show that the first appearance of man dates much farther back than is generally supposed.

1. Belgian scholars (especially Schmerling and Spring) found human bones and crudely made weapons of flint in the caverns of Gouffontaine and Chokier in the "Trou chauvan" between Namur and Dijon. These remains were accompanied by the bones of the cave-bear, hyena, lion, "schelch" deer, and a species of horse, in a manner which leaves no doubt as to their co-existence. Three fragments of human skulls were found there, which differ from all at present existing in Europe by being long and flattened out at the sides and by the shape of the forehead. They apparently belonged to an elderly man, a twelve-year-old and a seven-year-old child. Human lower jaws have also been found.

They are broader in front, and the chin forms a sharper angle backward, than in any of the present European races. These skulls, therefore, exhibit a prognathous form, which is only found in a low state of civilization.

2. In 1849 M. Boucher de Perthes, of Abbeville, in Northeastern France, announced that he had found strata of sand and alluvium, in which skeletons of extinct species of animals occurred, together with human weapons and tools of flint and stag-horn. Soon afterward Dr. Rigollot, of Amiens, made similar discoveries, and many excellent geologists, like Prestwich, Lyell, &c., who visited these regions since, agree that the human and animal remains found there are of the same date. Human bones have not been found there. Of the animal remains it is sufficient to mention the mammoth, the rhinoceros with divided nose, and the cave-hyena; the appearance of the reindeer is also of special interest.

Sir Charles Lyell described these discoveries in detail last fall in his opening address as president of the British Association. According to his statement the alluvium stratum has been explored to a distance of fifteen English miles, and has already furnished over 1,000 flint utensils. To explain such a numerous occurrence of these manufactures along with animal skeletons without the presence of human bones, Lyell instances a phenomenon observed by him on Saint Simon's Island, in Georgia, North America. There the traces of an old Indian settlement are visible in a stratum 5 feet thick and covering about ten acres, which contains oyster-shells, arrow-heads, stone hatchets, and fragments of Indian pottery. If now the Altamaha River were to wash away this stratum from the island and deposit it again farther along its course or at its mouth, we would have a deposit of numerous human manufactures, but without human bones, just as at Abbeville.

The occurrence of the reindeer along with human remains has recently again been confirmed by Mr. Prestwich, who found a flint weapon immediately under the horns of a reindeer in the cave of Brixham, England. This animal, as is well known, is very sensitive to milder temperatures; all attempts to acclimatize it in Northern Scotland have failed. It therefore follows, not only that man was the contemporary of the extinct large mammals of the first group, but also, from his simultaneous appearance with the reindeer, that he was a hunter in Central Europe already at the time when the climate was much severer than it is now.

If we compare these most ancient human remains yet discovered with those of the palafittes, which may be counted as belonging to the age of stone, we will perceive striking differences; first, the position of the palafittes proves certainly that the water-level of the Swiss lakes has not changed very considerably since their construction, and we may therefore conclude that the glacier period was past at the time of their construction. In some cases this can be fully proved. Among the remains found in them neither the reindeer nor any of the animals of the first or fourth groups occur. Tortoises, whose remains are found there, are cospecific with the European swamp-tortoise, the shells of which occur with human remains in Scandinavia, in peat in Hungary, and which, according to Tschudi, is even found alive in the Reuss Valley, Switzerland. Among vegetable remains numerous broken hazel-nut shells are remarkable, not because they were necessarily an article of food of the lacustrians, but because they belong to a plant, which was formerly widely distributed and whose fruit is even found in the peat of the Shetland Islands. Cereals have also been found.

The articles of human manufacture from the palafittes also differ from those of Abbeville and the Belgian caverns. They are not cleft but ground. Sherds of pottery-ware are only found in the former, and everything points to a higher civilization and to external circumstances, which could not have been very different from those of the present day. A pearl of amber found by M. Keller in the palafittes of Meilen, in Lake Zurich, is perhaps another proof that the eastern coasts of Prussia were the same then as now.

If we are warranted, therefore, in assuming the prevalence of a severe climate during the first division of the age of stone, because of the simultaneous occurrence of the reindeer and weapons of flint, and that the palafittes contain indications of conditions similar to the present, it follows that the last great changes in the temperature and the concomitant redistribution of land and water took place within the age of stone of the archæologists. And since the migration of organic beings, like that of the lowland flora of those times, to the Alps and to Scandinavia could only take place very slowly and under a very gradual change of climate, we must assume that the age of stone included an extremely long period of time.

The first progress of tribes in civilization is always slow, and the Hindoos do not show divine honors to Twachtri, who taught the preparation of brass, without a cause. No one knows how long before Pausanias the Sarmatian stuck to his arrows of bone-splinters, or how long the African has hurled his boomerang. At the time of Diodorus, the arms of the Libyan consisted of three light darts and a leather bag of stones. To-day the traveler finds the same weapons in the hands of the African.

Combining what has been said, the following appears to be the result of the most recent researches concerning the antiquity of man in Central Europe.

Even at a time when Central Europe was cold enough for the reindeer to live in Northern France, when the mammoth and the rhinoceros inhabited the swampy shores, and lions, hyenas, and bears the caves, when Great Britain was probably connected with the continent, and Scandinavia with Denmark, a race of men lived there who had prognathous skulls, and possessed only weapons of flint and bone-splinters to hunt food with and to protect themselves against these large beasts.

Gradually, in the course of thousands of years, the land sank, the sea separated parts from it, and a milder temperature prevailed. Then a portion of the flora and fauna slowly migrated, partly to the mountains, partly to the north, and partly to both. Many large animals like the mammoth, incapable of living in the mountains, remained behind; the lowlands at the lower part of the Rhine's course, which were probably the principal abodes of these large herbivorous animals, gradually sank below the present North Sea, so that they, exposed to an uncongenial climate, surrounded by a new immigrated flora not their original food, and subjected to the attacks of man, gradually died out. In the lowlands new species continually appeared, many after Ireland and some few after England had already become separated from the continent. Finally came new tribes of men with new arts, and we find the first traces of agriculture. Here the historian takes up the account from the geologist and palæontologist.

This sketch necessarily remained imperfect, because it was not possible to make it include all the further proofs furnished by the study of the present distribution of plants, of lower animals, (land-snails,) and especially of marine animals. It was also necessary to pass over all those phenomena which relate to the existence of a separate population in Western Europe. But perhaps what has been said will be sufficient to give a general idea.

Defenseless, like no other animal of the same size, man is born without sharp teeth, without claws, without any external means of defense, such as the fur of many beasts. The child is dependent a longer time on its mother than the young of any other animal, and no being is as helpless. And yet man has made himself the master of all. He has made a thousand instruments, fire, and the modulations of speech his own. The space of time, which now follows and which is called the Age of Man, exhibits one great, enduring, eminent characteristic—the progressive, irresistible triumph of the intellect.

EXPLANATION OF THE PRINCIPLES OF CRYSTALLOGRAPHY AND CRYSTALLOPHYSICS.[1]

By Aristides Brezina.

[TRANSLATED FOR THE SMITHSONIAN INSTITUTION BY PROFESSOR T. EGLESTON.]

INTRODUCTION.

Among all the methods in crystallography there is not a single one which has remained so completely confied within special limits as Miller's. The reason for this is not the abstract method in which the subject is treated, nor its difficult mathematical principles, but is principally owing to the fact that, up to this time, it has never been treated separately from those operations which serve for the derivation of certain special mathematical formulæ in the first principles of geometry.

Miller's method is really capable of an elementary treatment, which, almost without the use of mathematics, renders possible not only the quick and certain explanation of all combinations in the way of zone-observations, but also the recognition of the physical characters of crystals on the basis of their relations of symmetry.

These characters of this known method are especially useful for mineralogists and lithologists, who make microscopical observations: for the first, because he, without many measurements and calculations, can show, from only the simple inspection of a crystal, the connection of the different faces, together with the explanation of the combination; and for the latter, because he is in position, on account of a precise knowledge of the relations of symmetry, to recognize, in thin sections, both the crystalline system and the elements of a crystal; and in both cases, without presumption of such mathematical knowledge, which is without the departments of mineralogists and lithologists. This method is, for this reason, not only simple and fundamental, but is in every way superior to the others in use, which have originated with Weiss, Naumann, and Levy.

One of the most important advantages of it is the possibility of a simultaneous development of the crystallographic and physical relations of every system from its known symmetry. This method of procedure gives, from the very commencement, a complete insight into its habits and characteristics, and secures, during its development, a survey of the whole theoretical structure. But while this method of derivation was first carried out for the crystallographic part by von Lang[2], the introduction of Whewell's[1] method of notation of the faces of crystals was an important element in Miller's system.

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[1] Mineralogische Mittheilungen. Wien, 1872.

[2] Lang, Krystallographie. Wien, Braumüller, 1866.

Miller's symbols consist, as will be explained later, of three indices, which are inversely proportional to the intersections of the faces on the three axes; while in Weiss's system they are directly proportional. Naumann's and Levy's systems sometimes give sections of the axes and sometimes the relations betweeen two sections. The advantages of Miller's notations are very numerous: Chiefly it allows of representing every individual face; while Naumann's and Levy's symbols give only the form, *i. e.*, the re-union of all the faces which belong together. When it is necessary to represent the whole form in Miller's system, the symbol of the face is represented in parentheses; it has, therefore, the advantage, that, according as it is required, either the face or the form can be exactly and concisely designated.

Miller's symbol is, besides, exceeding simple and convenient. While here three low whole numbers, 0, 1, and seldom 2, are sufficient, in Weiss's system three or four fractions, and three or four letters, in groups of three or four, are required, separated by colons:

$$\boxed{\tfrac{1}{2}a : b : \infty c} \text{ or } \boxed{\tfrac{1}{2}a' : a' : 2a' : c}$$

In Naumann's, two fractions and a letter, with perhaps as many as four accents, as:

$$2\,\breve{P}\,\infty \text{ or } \tfrac{1}{3}\,{}'\breve{P}'_{,} : {}'2$$

Levy's symbols are, in many cases, complicated, as in pyramids:

$$b^{\frac{1}{2}}\ d^{1}\ d^{\frac{1}{3}}$$

where there are three letters and three fractions.

Naumann's, and Levy's symbols are not symmetrical with regard to the crystallographic axes, *i. e.*, while with Miller the first, second, and third indexes refer invariably to the first, second, and third axes, it is never the case with Naumann, and with Levy only in the most complicated cases (the pyramid of the second order) that every axis is represented by an index, and even in this case the signs of the axes change their position. This symmetry of axes is important, because it makes both the transformation of the indices in changes of axes, as well as the calculation of zone-equations, exceedingly simple and demonstrative.

Singularly enough, this side of Miller's symbols has been attacked because in Naumann's and Levy's symbols the difference between pyramids, prisms, domes, and pinacoids is apparent. This is, however, extremely unjust. In Miller's system, in the symbol of the pyramid, there are three 0's of different values. In the symbol of a prism or dome, an index is equal to 0; a pinacoid has the symbol (1 0 0), (0 1 0), or (0 0 1), which contains two 0's, and is certainly a difference which strikes the eye.

As opposed to the notation of Weiss, Miller's method, besides the brevity mentioned above, has the further advantage that, instead of the symbol ∞, zero is used, because the figures of both these systems are reciprocal. How great the importance of this particular is in the calculation of zone-equations will be immediately shown. On the facility of zone-development, however, depends the quick and sure solution of the combination.

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[1] Whewell, Phil. Trans., 1825, p. 87.

The method of establishing a zone-equation is, according to Miller, as follows: Given two faces, *efg* and *pqr*, the sign of the zone formed by both can be obtained by crosswise multiplication and subtraction, as follows:

$$\begin{array}{c} e\,f\,g\quad e\,f\,g \\ \times\times\times \\ p\,q\,r\quad p\,q\,r \\ \hline [fr-gq;\; gp-er;\; eq-fp] \\ [u \qquad\quad v \qquad\quad w] \end{array}$$

$[u\,v\,w]$ is the symbol of the zone; now, *efg pqr* are severally whole numbers; the products, fr, gq, gp, ..., are, for that reason, likewise so; the same is therefore true of their differences, which represent the indices $u\,v\,w$ of the zone.

If the face xyz lies in the zone represented by $[u\,v\,w]$, the similarly-situated indices of face and zone multiplied, and all three added together, must be equal to 0:

$$u\,x+v\,y+w\,z=0$$

A numerical example makes the brevity still more apparent:

$$\begin{array}{ll} a\,b\,c\ldots\ldots 2\,1\,0 & \quad 2\quad 1\quad 0\quad 2\quad 1\quad 0 \\ & \qquad\quad \times\;\times\;\times \\ p\,q\,r\ldots\ldots 1\,\bar{1}\,1 & \quad 1\quad \bar{1}\quad 1\quad 1\quad \bar{1}\quad 1 \\ \cline{2-2} & 1.1-0.\bar{1};\; 0.1-2.1;\; 2.\bar{1}-1.1 \\ & \quad 1-0; \qquad 0-2; \qquad -2-1 \\ u\,v\,w\ldots\ldots[1\,\bar{2}\,\bar{3}] & \quad 1 \qquad\qquad \bar{2} \qquad\qquad \bar{3} \\ x\,y\,z\ldots\ldots 3\,0\,1 & 1.3+\bar{2}.0+\bar{3}.1=3-3=0 \end{array}$$

The face 3 0 1, therefore, lies in the zone $[1\ \bar{2}\ \bar{3}]$, produced by 2 1 0 and $1\ \bar{1}\ 1$.

Let us observe the method of zone-calculation according to Weiss:* Given two faces—

$$\boxed{\alpha a : \beta b : n c} \quad \text{and} \quad \boxed{\alpha' a : \beta' b : n c}$$

which are already reduced to a similar co-efficient of *c*. The zone produced is—

$$(n\,c;\; \alpha''\,a+\beta''\,b)$$

therefore—

$$\alpha''=\frac{\alpha\,\alpha'\,(\beta-\beta')}{\alpha'\,\beta-\alpha\,\beta'};\; \beta''=\frac{\beta\,\beta'\,(\alpha-\alpha')}{\alpha\,\beta'-\alpha'\,\beta}$$

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* Weiss, Berliner academische Abhandlungen, 1820-21, pp. 169-173.

The values $\alpha\alpha'$, $\beta\beta'$, are therefore negative when the axes a or b, for which they stand, are primed ($a'\,b'$).

If the face—

$$\boxed{\alpha'''\,a : \beta'''\,b : n\,c}$$

lies in this zone, one of the following propositions must be right:

$$\alpha''' : \beta'' = \alpha'' \left\{ \begin{array}{l} \beta''' - \beta'' \\ \beta'' - \beta''' \\ \beta''' + \beta'' \end{array} \right\} = \left\{ \begin{array}{l} \alpha''' - \alpha'' \\ \alpha'' - \alpha''' \\ \alpha''' + \alpha'' \end{array} \right\} : \beta'''$$

The simple inspection of this method shows how minute in detail this method is. In the first place, the symbols of the faces, with respect to an axis, (in the above case c,) must be reduced to similar co-efficients; then by multiplication and addition, respective subtraction and division, the values α'' and β'' are to be determined. It is to be remarked that both the numerator and the denominator of these quantities are fractions, which must be reduced to a common denominator. The calculation, it is true, (*loc. cit.*, p. 169,) can be simplified when the symbols of the faces are written—

$$\boxed{\frac{1}{x}\,a : \frac{1}{y}\,b : n\,c}$$

This, however, is using Miller's symbols, which are the reciprocals of Weiss's; and even then the calculation is more circumstantial, because the three symbols are equated with reference to c, and are not symmetrical according to the three axes.

The steps of the calculation in the hexagonal system are still more incumbered, since, from a four-membered symbol a three-membered parameter must be first calculated, and then introduced into the previously-developed calculation.

Quenstedt* employs these symbols in his so-called zone-point formulæ in a somewhat more convenient, although in a much less concise, manner than Miller. Let there be three faces—

$$\boxed{m\,a : n\,b : c},\ \boxed{p\,a : q\,b : c},\ \text{and}\ \boxed{x\,a : y\,b : c}$$

whose tautozonality is to be proved. For every pair of these the zone-point formulæ must be written, and the verification as to whether the zones are identical, made. Thus, for the zone—

$$\boxed{m\,a : n\,b : c}\ \text{to}\ \boxed{p\,a : q\,b : c}$$

$$\frac{\frac{1}{q} - \frac{1}{n}}{\frac{1}{mq} - \frac{1}{pn}}\,a : \frac{\frac{1}{m} - \frac{1}{p}}{\frac{1}{mq} - \frac{1}{pn}}\,b \quad ;$$

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* Quenstedt, Mineralogie, 1863, p. 44.

The same must be done for the zone—

$$\boxed{ma : nb : c} \text{ to } \boxed{xa : yb : c}$$

$$\frac{\frac{1}{y}-\frac{1}{n}}{\frac{1}{my}-\frac{1}{xn}}\,a : \frac{\frac{1}{m}-\frac{1}{x}}{\frac{1}{my}-\frac{1}{xn}}\,b$$

from which, as a condition of tautozonality, follows the equality of both relations. Quenstedt and P. Klein* employ the zone-control in this form.

It is to be remarked that these zone-point formulæ can be essentially simplified, because the denominators of both sides are alike; thus—

$$\left(\frac{1}{q}-\frac{1}{n}\right)a : \left(\frac{1}{m}-\frac{1}{p}\right)b \text{ and } \left(\frac{1}{y}-\frac{1}{n}\right)a : \left(\frac{1}{m}-\frac{1}{x}\right)b$$

Also, the condition—

$$\left(\frac{1}{q}-\frac{1}{n}\right) : \left(\frac{1}{m}-\frac{1}{p}\right) = \left(\frac{1}{y}-\frac{1}{n}\right) : \left(\frac{1}{m}-\frac{1}{x}\right)$$

But this equation is much more complicated than Miller's. In our former example we had—

$$210 = \tfrac{1}{2}a : b : \infty c \,;\; 1\bar{1}1 = a : b' : c ;\; 301 = \tfrac{1}{3}\, a : \infty b : c$$

Exchanging the axes a and c in all the three faces, in order to be able to make the co-efficient of c equal to unity, which has no influence on the tautogonality, we have—

$$\infty a : b : \tfrac{1}{2}c \,;\; a : b' : c \,;\; a : \infty b : \tfrac{1}{3}c$$

or—

$$\infty a : 2b : c \,;\; a : b' : c \,;\; 3a : \infty b : c$$

It follows that—

$$\frac{1}{m}=0 \,;\; \frac{1}{n}=\frac{1}{2} \,;\; \frac{1}{p}=1 \,;\; \frac{1}{q}=-1 \,;\; \frac{1}{x}=\frac{1}{3} \,;\; \frac{1}{y}=0$$

by substitution—

$$\left(-1-\frac{1}{2}\right) : \left(0-1\right) = \left(0-\frac{1}{2}\right) : \left(0-\frac{1}{3}\right)$$

or—

$$-\frac{3}{2} : -1 = -\frac{1}{2} : -\frac{1}{3}$$

The proportion is correct, consequently the zones exist. The numerical values of the letters must here, also, be substituted according to the above-mentioned method, and the division carried out; while in Miller's method the very simple and symmetrical calculation can be carried out on the indiçes, without the help of letters, by means of the crosswise multiplication and subtraction of whole numbers.

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* Klein; Leonh. Jahrb., 1871, p. 480.

Naumann's method is still more circuitous: first, Weiss's parameters must be calculated, and then they must be introduced into the equation—

$$\frac{1}{a\,b'\,c''}+\frac{1}{b\,c'\,a''}+\frac{1}{c\,a'\,b''}=\frac{1}{a\,b''\,c'}+\frac{1}{b\,c''\,a'}+\frac{1}{c\,a''\,b'}$$

in which $a\,b\,c$, $a'\,b'\,c'$, $a''\,b''\,c''$, represent the parameters of the faces. If these numbers contain two figures, as is frequently the case in the hexagonal system, there must be twelve multiplications, six divisions, and the addition made. The division must be carried out to four decimal places, and sometimes farther; while in Miller's system the convenience of a calculation with whole numbers is always secured.

This circuitous course has caused the adherents of the schools of Naumann and Weiss, to this day, to use Quenstedt's method; and they are contented with an approximative zone-verification, while, since the foundation of Miller's method, even the beginner is both capable of and accustomed to verify every zone by means of the exceedingly simple calculation of zone-equations. In fact, Kohscharow,[1] in the year 1866, again first called attention to the zone-verification calculation, which, since the publication of Weiss, had been almost entirely forgotten; von Rath,[2] Hessenberg,[3] and C. Klein[4] followed, replacing the construction in specially-complicated cases by calculation.

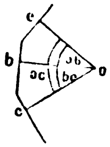
The use of the angle of the normal to the faces, instead of the interior angle of the solid, is also important: in the first place, with respect to convenience and conciseness, while, as a rule, the interior angle is greater than 100°, and therefore contains three figures, the angles of the normals have, for the most part, two figures; further, the angles measured at present with the reflecting-goniometer are for the most part angles of normals. In the simple evaluation of an angle with the eye even the supplement is easier to estimate than the real angle, because it is generally smaller.

The most important advantage of normal angles is, that they can be immediately introduced into the calculation. This is especially apparent in tautozonal faces, in which, from two angles of every two out of three tautozonal faces, the third can be had by simple addition or substraction, (Fig. 1,) as—

$$\sphericalangle\, a\,b + \sphericalangle\, b\,c = \sphericalangle\, a\,c. \quad \sphericalangle\, a\,c - \sphericalangle\, a\,b = \sphericalangle\, b\,c$$

which is not the case with the angles made by the faces themselves.

Fig. 1.



In the determination of combinations a very quick orientation is furnished by this method. Lastly, only normal angles are suitable for introduction in spherical projections, where they themselves directly form the sides of the spherical triangle.

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[1] Von Kohscharow, Materialien zur Mineralogie Russlands, 1866, p. 216.

[2] Von Rath, Pogg. Ann., cxxxii, 1867, p. 398.

[3] Hessenberg, Min., Not. ix in Seuchenb. Ges., Abh. vii, 1870, p. 259.

[4] Klein, *loc. cit.*, p. 481.

This also shows one of the advantages of the method of spherical projections, which is entirely wanting in Quenstedt's system. Since, further, Miller's entire method of calculation is based upon spherical trigonometry, the illustrating figure is shown on the projection, which, therefore, at the same time represents the zone-connection of the form and the method of the calculation of the crystal.

Spherical projection has, finally, the great advantage of being limited, so that the geometrical situation of all faces can be actually delineated, and can be united in a comprehensive representation, a characteristic which is wanting both in the gnomonic method and that of Quenstedt. In this way alone it is possible to use projection for the introduction of all the physical relations, which circumstance, on account of its increasing use, is a very important one.

A reproach, which, although perhaps not expressed, still is silently made against this method of projection, is that in its construction triangles and dividers are necessary, while with Quenstedt's method triangles alone are used. This reproach is, however, entirely without foundation; for, in the first place, dividers are necessary for every exact projection, even if only the convenient form provided with steel points; but for general use both triangles and dividers are unnecessary, because on account of the extraordinary simplicity of zone-calculation the adherents of Miller's system of spherical projection are accustomed to use it only for representing and not for investigating existing zones, and they may therefore save themselves the trouble of making an exact drawing, unless they intend to publish.

To the many advantages of Miller's method no one has yet been able to oppose a disadvantage. If, in spite of this, it has not yet generally found its way into Germany and France, it is owing solely to the fact that in these countries Haüy, Weiss, and Naumann have taught; but when such completely independent theories are offered, the learner satisfies himself for the most part with the system which has been expounded; or if he afterward goes beyond that, the system to which he was first accustomed is easier, and his knowledge of it more fundamental, so that he does not become acquainted with many of the advantages of the new system.

The introduction of the Whewell-Miller principle was tried in Germany by Frankenheim, and in France by Bravais and de Senarmont, without, however, any permanent result. Recently the young german school, on account of the prominence to which the physical examination of crystals has attained, begins to make itself master of detached parts of Miller's method.

The purpose of the following pages is summarily to develop what is necessary for the solution of a combination, or for the knowledge of the physical nature of a crystal. We shall, therefore, in the first section, treat, according to Miller's method, the pure geometrical relations of a crystal, so far as they are requisite for the determination of combinations.

The second section treats of the possible systems of crystallization and their corresponding relations of symmetry; it is taken as an abstract from the work of von Lang. In the third section I have shown how, with the foundation of the optical relations of a crystal in general, the optical characters for each individual system of crystallization are derived from their symmetry.

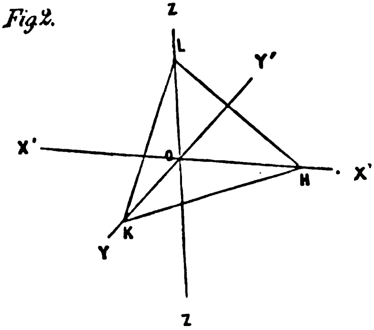
SECTION I.

THE GEOMETRICAL RELATIONS OF CRYSTALS.

§ 1.—MILLER'S SYMBOLS.

It is well known that the situation of any plane is perfectly defined when its sections, *o* H, *o* K, *o* L, (Fig. 2,) of three straight lines, *o* X, *o* Y, *o* Z, which are not parallel, and which have a common origin, *o*, are known. These straight lines are called the axes; the point *o* the center of the axes; the plane of every two axes, X *o* Y, Y *o* Z, Z *o* Y, the planes of the axes; and the sections *o* H, *o* K, *o* L, the parameters of the face H K L.

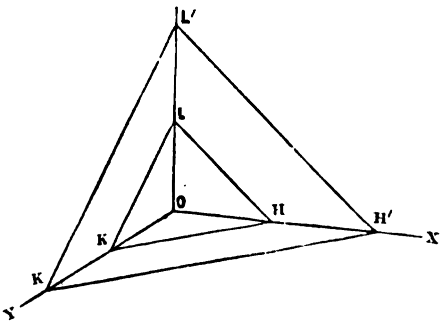
Fig 2.



Because every axis considered in regard to O has two sides, these are distinguished as the positive and negative half-axes. For this reason the sections of the axes are used in the calculation as + *o* H or − *o* H.

The lines joining every two sections of the axes of a plane, (H K, K L, L H,) give the intersection of the plane H K L with the three planes of the axes.

Fig 3



If we multiply the three parameters of a face with the same number, the direction of the plane remains unchanged; it will only be moved parallel to itself, (Fig. 3.)

From the equality of the relation—

$$\frac{o\,H'}{o\,H} = \frac{o\,K'}{o\,K} = \frac{o\,L'}{o\,L} = m$$

results the similarity of the triangles K O L, K′ O L′, &c., and from this the parallelism of H K L and H′ K′ L′.

If another face, A B C, is given, with the parameters o A, o B, o C, which we may call a, b, c, then—

$$o\,\mathrm{A} = a;\quad o\,\mathrm{B} = b;\quad o\,\mathrm{C} = c$$

and the face H K L is determined when the relations—

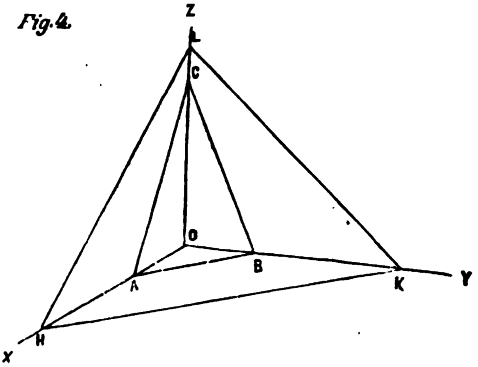
$$h = \frac{o\,\mathrm{A}}{o\,\mathrm{H}} = \frac{a}{o\,\mathrm{H}};\quad k = \frac{o\,\mathrm{B}}{o\,\mathrm{K}} = \frac{b}{o\,\mathrm{K}};\quad l = \frac{o\,\mathrm{C}}{o\,\mathrm{L}} = \frac{c}{o\,\mathrm{L}}$$

are known; so a third face, H′ K′ L′, is determined by its relations or indices h' k' l', in which—

$$h = \frac{a}{o\,\mathrm{H}'};\quad k' = \frac{b}{o\,\mathrm{K}'};\quad l' = \frac{c}{o\,\mathrm{L}'}$$

We see, also, that if three planes, X o Y, Y o Z, Z o X, are given, whose three lines of section represent the axes o X, o Y, o Z; further, a fourth face, A B C, whose section of these axes is the measure of the length of the axes, any face in their direction is perfectly determined when its indices, *i. e.*, the relation between the parameters of A B C and its own, are given.

Fig. 4.



The values a b c and the plane of the axes are constant for one and the same crystal.

Respecting the indices h, k, l, certain important cases are to be distinguished:

I. All three of the indices may be different from (o h, k, l,) $\gtrless o$. This is the general case, and represents octahedral or pyramidal faces.

II. One index, l, for instance, equals zero, $l = o$; the face h, k, o, is evidently parallel to the axis o Z, and we have—

$$l = \frac{o\,\mathrm{C}}{o\,\mathrm{L}} = \frac{c}{o\,\mathrm{L}} = o$$

Because o C $= c$ is constant, this fraction can only be equal to o if o L is infinitely great; but if the face H K o cuts the axis o Z at an infinite distance, it is parallel to it. Thus, if $k = o$, we have $h\ o\ l$, and if $h = o$, we have $o\ k\ l$ of the axis of Y, parallel faces with respect to X. These kinds of faces are called dodecohedral, prismatic, or dome-faces.

III. Two indices $= o\ k = l = o \ldots.1\,0\,0$; $l = h = o = 0\,1\,0$; $h = k = o \ldots.0\,0\,1$, the face 1 0 0 has first the index $k = o$, and is for that reason parallel to the above axis of Y, and also to the axis of Z, because $l = o$. This face contains, therefore, both the axes of Y and Z. It is with them parallel to the axis-plane X o Z. We call such faces pinacoids; they are those by means of whose section-line the position of the axes is determined.

If the planes of the axes are parallel faces, X *o* Y, Y *o* Z, Z *o* X, as the faces A B C and H K L, which may be real or possible faces of a crystal, experience shows that the indices *h k l* of every possible face of this crystal are to each other as rational numbers.

This law, which is the first fundamental law of crystallography, is called the law of rational indices; it is of the greatest importance, and allows of the derivation of the greater part of the other laws of crystallography.

If the indices *h k l* of any face of a crystal are rational, it is always possible to represent them by three positive or negative whole numbers, because the direction of a plane remains unchanged when its three indices are multiplied by the same number.

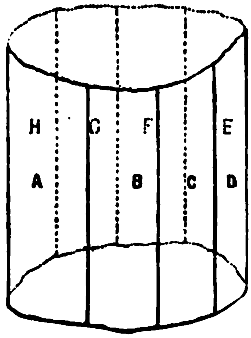
Experience shows further that the indices of the most frequently occurring faces are almost always the simplest whole numbers 0 and 1, rarely 2, so that the calculation with them will always be very simple.

§ 2.—LAW OF ZONES.

The consideration of the zones occurring in a crystal is of the greatest importance for the determination of a combination.

Two planes which are not parallel always cut each other, when duly extended, in a straight line; all planes, therefore, whose lines of section are parallel to the same straight line, belong to a zone, and are called tautozonal faces; the straight line to which their lines of section are parallel is called the axis of the zone. (Fig. 5.)

Fig. 5



Because the axis of a zone is parallel to all the faces of that zone, a plane, P, perpendicular to the axis of the zone, will also be perpendicular to all the faces of that zone; and when a perpendicular to every zone-face is erected, all of these normals will be parallel to this face P. This important characteristic of tautozonal faces, that their normals all lie in a plane perpendicular to the zone-axis, we shall make use of in the discussion of spherical projection.

After the direction of the zone-axis is determined by the section of two planes which are not parallel, it must be possible, from the known elements of these planes, to calculate for the indices such values as will be characteristic for the axes of the zone produced by these planes. Let P (*h k l*) and Q (*p q r*) be the two planes, and let their indices be written twice, one over the other, and multiplied crosswise, beginning with the second upper index *k*—

$$\begin{array}{c} h\ \ k\ \ l\ \ h\ \ k\ \ l \\ \times\ \times\ \times \\ \underline{p\ q\ r\ \ \ p\ q\ r} \\ kr - lq;\ lp - hr;\ hq - kp \\ u \qquad\qquad v \qquad\qquad w \end{array}$$

Subtracting now the products obtained by multiplying the index right above with that left below, from that obtained by multiplying the index left above with that right below, we obtain three whole numbers $(u\,v\,w)$, which are either positive or negative, are determined for the zone P Q, and are called zone-indices. In order to distinguish these from the indices of the faces, they are inclosed in rectangular brackets.

The zone-indices of a zone containing more than two faces can be calculated from any two faces of the zone which are not parallel. The same value is always obtained, abstraction being made of a constant factor of all three indices, with which we can always multiply all of them without changing the direction of the face or line represented.

If, now, a third face, R$(x y z)$, is placed in the above zone P O, we have a simple criterion, whose expression is produced from the fact that the zone-axis [P R] or [Q R] must have the same indices, even to a constant factor, as [P Q]. This criterion is the existence of the equation—

$$ux + vy + wz = o$$

If this equation is realized, all the three faces P Q R are in the same zone. If the symbols of two zones, $[e f g]$ and $[u v w]$, are given, the symbol of a face $(x y z)$ lying in both zones may again be found by crosswise multiplication—

$$\begin{array}{cccccc} e & f & g & e & f & g \\ & \times & \times & \times & & \\ u & v & w & u & v & w \\ \hline \multicolumn{6}{c}{\underset{x}{fw - gv};\ \underset{y}{gu - ew};\ \underset{z}{ev - fu}} \end{array}$$

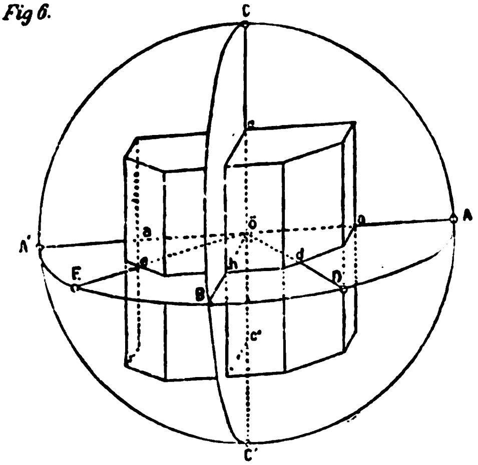
in the same way as the zone-symbol from the indices of two faces.

At the close of this section the most important special zone-laws and some examples of the development of zones will be given.

§ 3.—Spherical Projection.

The method of spherical projection introduced by Naumann gives the simplest means of representing the opposite faces of a crystal. It has the advantage of showing, even in extremely rough executions of it, a representation of the zone-combinations of a crystal, and allows of the determination of the indices of its faces, on the assumption of a primitive form, almost without any measurements.

Fig 6.

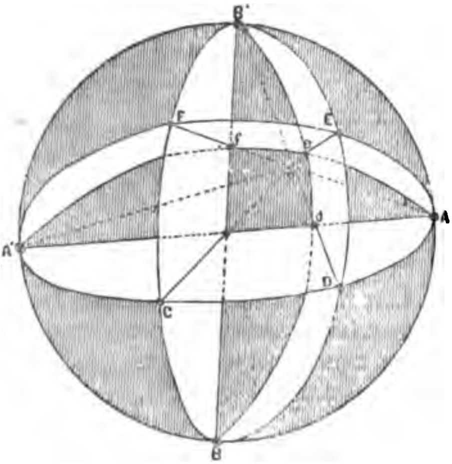


For this purpose let us imagine that from a point o, in the interior of a crystal, (Fig. 6,) perpendicular straight lines, $o\,a$, $o\,a'$, $o\,b$, $o\,c$, $o\,c'$, $o\,d$, $o\,e$, be drawn to all of its faces. From the point o, as a center, let us construct a sphere of any radius, and produce the perpendiculars until they cut the sphere A A′ B C C′ D E, &c., which are called the poles of the faces, which they meet.

In this construction, in which, for the sake of distinctness, only the front side is drawn, we see immediately that the poles of tautozonal faces, A D B E A′ for instance, lie in a great circle of the sphere, because the normals of tautozonal faces lie in a plane, which must pass through *o*, from which point all the normals are produced; a plane passing through the middle point, however, cuts the sphere in a great circle, which consequently contains the pole of the tautozonal faces.

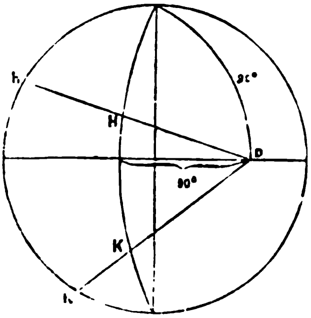
In order to draw a sphere containing the poles of the faces of a crystal, we may select several different methods of projection. Of these the stereographic method, introduced by Miller, is the most convenient.

Fig 7.



As plane of projection let us take, for this purpose, a plane passing through the center of the sphere *c*, (Fig. 7) which, according to the above, cuts the sphere in a great circle, A B C; let us draw a diameter of the sphere, O C, perpendicular to this, whose extremities, O and C, are 90° from every point of the principal circle, so that the lower pole O shall be the point of sight; let us now join by a straight line every pole of the sphere A B C D E F . . . . with the point of sight O. The intersections A B *c d e f* . . . . of these straight lines with the principal circle give the stereographic projection of the pole A B C D.

Fig 8



In general, the principal circle will be taken perpendicular to the faces of a zone, so that the projection of these points of the faces will be the periphery of the circle.

The most important peculiarities of such a projection are the following:

1. Every circle will be projected on the sphere, either as a circle or a diameter.

2. Every great circle will be projected on the sphere as an arc, which cuts the principal circle in the extremities of a diameter of the zone, or as a diameter itself. In such an arc, for that reason, also, the poles of the tautozonal faces lie, as, for instance, A *e f* A′; B *d e* B′; B *c f* B′; A *d c* A′.

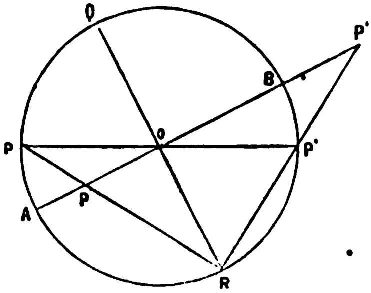
3. Let every point, P, which, on the sphere, is at 90° from all points of this circle, be the pole of a zone-circle, H K, (Fig. 8,) which is also the

projection of a face perpendicular to the zone-faces. The proposition obtains that the normal angle of two faces, H and K, is equal to the arc *h k*, which is cut off from the principal circle by the straight lines P H and P K produced.

From these three characteristics all the laws for the construction of stereographic projection are derived.

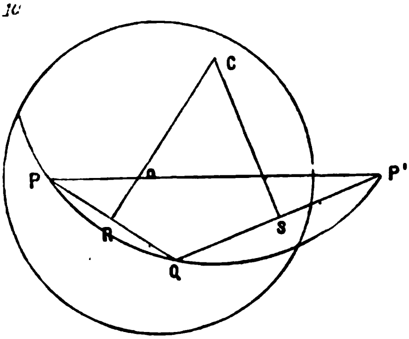
It is immediately apparent that the normal angle of all faces projected by points on the principal circle are determined by the arcs contained between the poles; that all zones passing the center of the main circle will be projected as diameters; that, further, the pole of such a zone falls again in the principal circle, and will be on one of the extremities of the diameter perpendicular to the zone.

Fig. 9.



If the projection of a pole, P, (Fig. 9,) is given, and that of the opposite face parallel to it sought, it is at once clear that it must lie outside of the principal circle. If a zone is determined by P and the center, *o*, of the main circle, the opposite pole P′ must be in the same zone, because every zone in which a face lies must also contain the opposite face which is parallel to it. In the zone P O we have now only to look for the point at 180° from P in order to determine P′. For this purpose we must, according to the third characteristic of projection mentioned above, draw from one of the points R or Q, which, as before, represent the pole of the zone P O, the point R for instance, a straight line, R P *p*, to its intersection with the principal circle; find the point *p′* of the principal circle, which is, at the required angle, 180°, from *p*; and then draw a straight line, R *p′* P′, whose section with the zone P O gives the pole opposite to P.

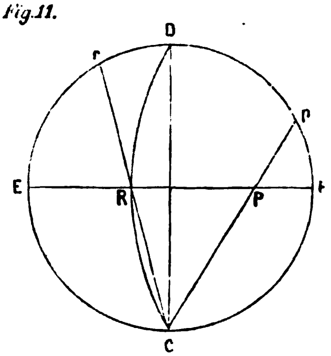
Fig. 10



If two poles, P Q, (Fig. 10,) be given, and the zone passing through them be sought, we look for the opposite pole of one of them, P′ for instance, which in any case must lie in the zone P Q. Through the three points P Q P′ we draw, according to the known method, (erection of a perpendicular in the middle of a line joining any two points,) an arc, which represents the required zone.

In order to find the pole of a given zone, C R, (Fig. 11,) we must consider that it must be 90° distant from every point of the zone-circle. If, now, C,D are the points of section of the zone with the main circle, we draw the diameter C D and a perpendicular to it, E F, and it is clear that the pole sought for must lie in the zone E F. Since, now, it must be 90° distant from every point of the zone, and therefore also from R, while the pole of the zone E F is one of the points C or D, we draw the straight line C R *r* and C P *p*, so that the arc *r p* = 90°, and thus find the pole *p* of the zone C R D.

Fig. 11.



Thus, all the expedients are given which are necessary for the construction and use of the projection; in general, the simplest of these are sufficient, especially while in this method of projection we do not aim at the greatest exactitude attainable, but only a presentable representation of the arrangement of the faces.

As a close of this section we shall give some special modes of the laws of zones, and an example of a complete development of them.

1. Zone passing through two pinacoids—

$$\begin{array}{l}100\ \ 100\\ 010\ \ 010\\ \hline 0.0-0.1;\ 0.1-1.0;\ 1.1-0.0\\ \quad\ 0 \qquad\quad\ \ 0 \qquad\quad\ \ 1\end{array}$$

[0 0 1] is the symbol of the third pinacoid. If a face, *h k l*, lies in this zone, so must—

$$h.o+k.o+l.1=o$$

also, $l=1$, the general symbol of a face lying in the zone $1\,0\,0.0\,1\,0=$ [0 0 1] is *h k o*.

2. Zone passing through a pinacoid and any face:

$$\begin{array}{l}h\,k\,l\ \ h\,k\,l\\ 100\ \ 100\\ \hline k.o-l.o;\ l.1-h.o;\ h.o-k.1\\ \quad\ o \qquad\qquad l \qquad\qquad \bar{k}\end{array}$$

If a third face, *x y z*, lies in the zone $[o\,l\,\bar{k}]$, so must—

$$x.o+y.l-k.z=o$$

or—

$$y\,l=kz;\ \frac{y}{z}=\frac{k}{l}$$

If, therefore, a zone passes through a pinacoid, the relation of those two indices, which, in the symbol of the pinacoid, are *o*, is constant for all the faces of this zone.

3. The cases given under the second and third rules are special cases of a more general one; and, certainly, two given faces, $(h\,k\,l)$ and $(p\,q\,r)$, in which—

$$\frac{k}{l}=\frac{q}{r}$$

can always be so represented that their symbols have the form $(e\,u\,v)$ and $(x\,u\,v)$, because the three indices of a face may be multiplied by the same number without changing the symbol.

For the zone we have—

$$\begin{array}{l} e\,u\,v \quad e\,u\,v \\ \underline{x\,u\,v \quad x\,u\,v} \\ u\,.\,v-v\,.\,u;\ v\,.\,x-e\,.\,v;\ e\,.\,u-u\,.\,x \\ \qquad o; \qquad v\,(x-e);\ u\,(e-x) \end{array}$$

or, if we divide the three zone-indices by $(x-e)$, $[0\,v\,\bar{u}]$; a face, $(r\,s\,t)$, lies in this zone, if—

$$o\,.\,r+v\,.\,s-u\,.\,t=o$$

so—

$$\frac{s}{t}=\frac{u}{v}$$

Let any two faces of a zone be represented by the symbols $(x\,u\,v)$ and $(e\,u\,v)$, or, generally, let them have two similarly-situated indices in both faces with like relations, all the faces of this zone will be represented in the form $(p\,u\,v)$.

That the second law comes also under this head is clear, because the relation $\frac{o}{o}$ is indeterminate, and therefore can answer to every value.

As an example of development by zones, we have chosen the crystal represented in Fig. 12. Because we assume that there are no measurements, but only the data of the zones, we shall presume, in the projection, (Fig. 13,) that it is triclinic. In this projection we record the faces in the order in which they are to be determined.

Fig. 12.

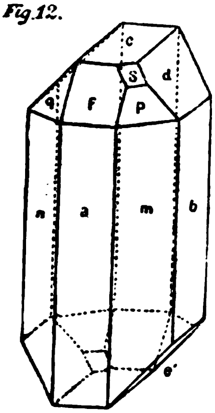
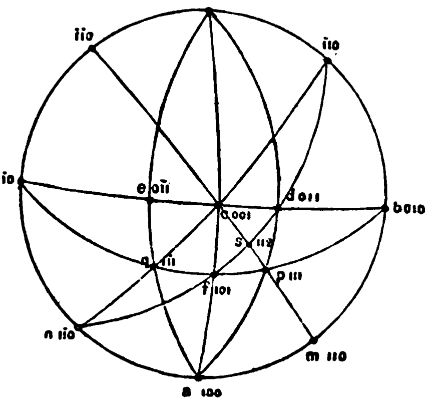


Fig. 13.



Let the zones to be determined be—

bman; bdce; afc; apd; bpfq; cspm; dsfn; cqn; aqe

The existence of these will be seen principally from the parallelism of the respective edges. Where there is no real edge, as is the case in the angle *aq*, the hypothetical zone-axis can be found by turning the crystal round. All faces which, in turning round the same axis, reflect the light are tautozonal.

In order to determine the combination, it is first necessary to select a system of axes. Regard will be had to the real or apparent symmetry of the crystal, in this way, that when a system less symmetrical in completeness and inclination of the faces approaches one of higher symmetry, this analogy is retained.

We select three faces, *abc*, for the planes of the axes; their lines of section give the crystallographic axes. We project these in such a way that the zone *ab* is contained in the principal circle.

The exactitude of the relation of the angles makes naturally no difference, if it is only a question of the solution of the combination. The faces are introduced into the projection in the order in which they are to be determined, first *a b c*.

The faces *a b c* then are designated by the symbol belonging to the pinacoids, 1 0 0, 0 1 0, 0 0 1.

In order to fix a ground-form, we have yet to determine the relations of the axes; this, according to the relation of *p*, may be (1 1 1); the axes-sections of the face *p* give also the value *o* A, *o* B, *o* C, from which the parameters of every other face will be determined.

That the indices of *p* must be 1 1 1 follows from the equation (p. 9) in which the indices of a face are determined, as—

$$h = \frac{o\,A}{o\,H};\ k = \frac{o\,B}{o\,K};\ l = \frac{o\,C}{o\,L}$$

Substituting the section *o* A, *o* B, *o* C, in this equation, we have—

$$h = k = l = 1$$

After the outline and the axes of the crystal are determined, the drawing of the faces can be developed.

Determination of *m*. *m* lies in the zones *b m a n* and *c....p m*. In order that a face may lie in the first zone, it is a necessary and sufficient condition that it has the symbol *h k o*, that is, is parallel to the axis *c*, as also follows from the derivation of the zone-equation.

For the second zone we have the condition—

$$\frac{k}{h} = 1$$

because, as we have seen, the equality of the same index-relations, in two faces of a zone, determines their equality for all the faces of that zone; thus—

$$\frac{h}{k} = \frac{1}{1} = \frac{0}{0}$$

This results also from the zone-equation—

$$\begin{array}{l} 1\,1\,1 \quad 1\,1\,1 \\ \underline{0\,0\,1 \quad 0\,0\,1} \\ 1\,.\,1-0\,.\,1;\ 1\,.\,0-1\,.\,1;\ 1\,.\,0-0\,.\,1 \end{array}$$

which gives $[1\,\bar{1}\,0]$ as the zone-equation, or—

$$1\,.\,x-1\,.\,y+0\,.\,z=0 \text{ or } x=y$$

as condition of the tautozonality of a face, $x\,y\,z$, with 0 0 1 and 1 1 1; the symbol of $m\,h\,k\,o$ becomes changed under these circumstances into (1 1 0).

In the same way the position of *d*, in the zones *b d c* and *a p d*, is determined. The first zone gives, as condition, the first index as equal to 0, it is thus $o\,h\,l$; the second gives the equation of the second and third index—

$$\frac{k}{l}=\frac{1}{1}=\frac{0}{0}=1$$

and therefore the symbol (0 1 1).

Finally, the face *f* is determined in the same way by the zone *a f c*, as $h\,o\,l$, and by the zone *b p f*, as 1 0 1, because—

$$\frac{h}{l}=\frac{1}{1}=\frac{0}{0}=1$$

Thus it is to be kept in view that the quotient $\frac{0}{0}$ may have any rational value which is first fixed by the two faces.

For the face *n* we have the zone *b m a n*, by which we get the symbol $k\,h\,o$ and *d f n;* for the last we have—

$$\begin{array}{l} 0\,1\,1 \quad 0\,1\,1 \\ \underline{1\,0\,1 \quad 1\,0\,1} \\ 1\,.\,1-0\,.\,1;\ 1\,.\,1-0\,.\,1;\ 0\,.\,0-1\,.\,1 \end{array}$$

or $[1\,1\,\bar{1}]$; also as condition—

$$h\,.\,1+k\,.\,1-0\,.\,1=0 \text{ or } h=-k$$

This condition is satisfied by $1\,\bar{1}\,0$ and $\bar{1}\,1\,0$, of which the first is the symbol for the face in front, and the last for the opposite one behind.

For the determination of *q* we have the zones *c q n* and *d p f q;* the first gives, when $h\,k\,l$ is the symbol of *q*—

$$\frac{h}{k}=\frac{1}{-1}=\frac{0}{0}=-1 \text{ or } (h\,\bar{h}\,l)$$

the last—

$$\frac{h}{l}=\frac{1}{1}=\frac{1}{1}=1 \text{ or } (h\,\bar{h}\,h)$$

which, when contracted, is $1\,\bar{1}\,1$.

The face *e* lies in the zone *b d c e*, wherefore $h=o$; and in *a q e*, for which reason—

$$\frac{k}{l}=\frac{-1}{1}=\frac{0}{0}=-1$$

e has thus the symbol $(0\,\bar{1}\,1)$.

There remains *s* in the zones *m p s e* and *d s f n* to be determined; the first zone gives—

$$\frac{h}{k}=\frac{1}{1}=\frac{1}{1}$$

or the general symbol $h\,h\,l$; and has $[1\,1\,\bar{1}]$ for its zone-index, so—

$$h + h - l = 0 \text{ or } 2\,h = l$$

which condition is satisfied by (112).

Thus the collective forms of this combination are determined.

There certainly may be cases presented where the existing zones do not suffice to determine all the faces of a combination; these cases are, however, rare, and occur in very few instances.

Instead of the above selection of a face, (111), determining the collective relations of the axes, two domes in two pinacoid zones could very well be used, as 1 1 0, in which $a : b$, and 1 0 1, by which $a : c$, is determined.

In the simpler and often recurring faces, as we have seen above, even the very simple calculation of the symbols from two zone-symbols, by crosswise multiplication, is superfluous, because at least the conditions for it, in a zone, can be at once expressed in the general symbol of the face, so that by substitution in the equation—

$$h\,x + k\,y + l\,z = 0$$

the indices $h\,k\,l$ are fully determined.

SECTION II.

SYMMETRY OF THE SYSTEMS OF CRYSTALLIZATION.

§ 1.—Derivation of the System from the Law of Rational Indices.

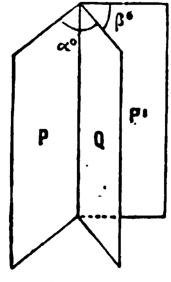
The rationality of the indices is, for the possibility of a face of a crystal, as we have said above, not only a necessary but a sufficient condition. It is, therefore, a possibility of every face whose indices are rational numbers. A collection of faces, therefore, which is to obey the law of rational indices must also answer to all the consequences which in mathematics follow from this law.

The carrying-out of this deduction, which can here only be announced, leads us to the different elements of symmetry, and especially to the consideration of planes of symmetry.

A plane of symmetry has the peculiarity that its physical relations are equal on both sides of it.

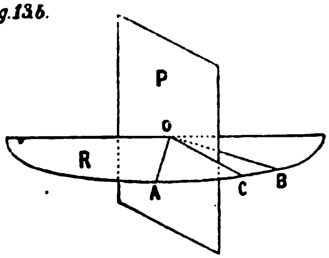
The identity of the physical peculiarities of two faces or lines is also determined by the similarity of their position with respect to the plane of symmetry, and this condition is really fulfilled by two planes when they are tautogonal with the plane of symmetry, and are so situated with regard to both sides that they form like anzles with them, (Fig. 13a, where the angle P : Q = α° and P^1 : Q = β° are equal to each other.) Two lines, o A and o B, (Fig. 13b,) satisfy the condition if they, with respect to the plane of symmetry P, contain a similar angle; and if a plane, R, at right angles to the plane of symmetry can be passed through, then arc A C = arc C B.

Fig. 13. a.



The derivation of the crystalline system is as follows: Let two possible faces of a crystal be taken which are symmetrical with respect to a plane; it is to be determined if symmetry with regard to another plane does not follow from it; given a zone, which is symmetrical with respect to one or more faces, *i. e.*, that for every face of the zone there is also a possible one which will be symmetrical with it, it is required if from this, symmetry in other directions does not follow, *i. e.*, if for every possible face of the given zone another face is not also possible, with which, according to presumption, the zone sought for is parallel.

Fig.13b.



The criterion of the possibility of a face is, therefore, always the rationality of its indices. Proceeding in this way, we recognize that only that reunion of faces is, crystallographically speaking, possible, which, by the number and position of their planes of symmetry, belong to one of the seven characteristic crystalline systems. By plane of symmetry of a crystal we understand a plane in relation to which all the possible faces of a crystal are symmetrical, so that for every possible face of a crystal there is another which, so far as the plane of symmetry is concerned, is symmetrical with it. It is therefore apparent, that only the following combinations are possible:

Fig.14.

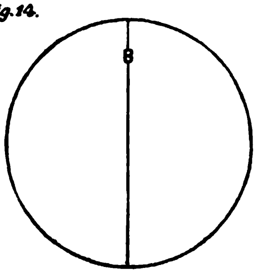
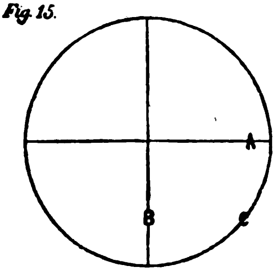


Fig.15.



1. No plane of symmetry existing................ TRICLINIC SYSTEM.
2. One plane of symmetry, B, (Fig. 14)........ MONOCLINIC SYSTEM.
3. Three different planes of symmetry at right angles to each other, A, B, C, (Fig. 15)........... RHOMBIC (ORTHORHOMBIC) SYSTEM.

Fig.16

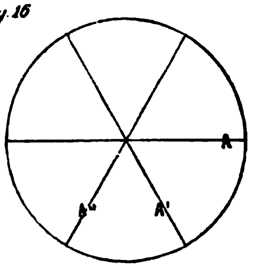
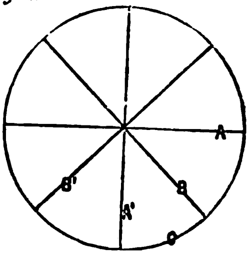


Fig.17.



4. Three tautozonal and similar planes of symmetry inclined to each at angles of 60° and 120°, A A′ A″, (Fig. 16), RHOMBOHEDRAL SYSTEM.

5. Five planes of symmetry, of which four are tautozonal and inclined to each other 45° and 90°, every two 90° apart similar, A A′, A′ A″, (Fig. 17.) The fifth, C, at right angles to all the others, and not similar.............................. TETRAGONAL SYSTEM.
6. Seven planes of symmetry, six of which are tautozonal and inclined 30° and 60°, every three 60° apart, similar, A A′ A″, B B′ B″, (Fig. 18.) The seventh, C, at right angles to all the others, not similar .... HEXAGONAL SYSTEM.

Fig. 18.

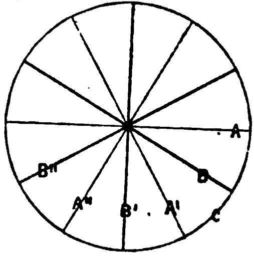
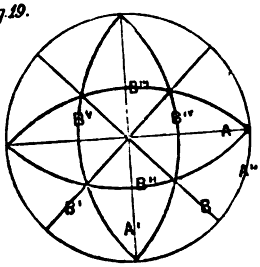


Fig. 19.



7. Nine planes of symmetry, three of which, A A′ A″, (Fig. 19,) are at right angles to each other, and similar. The other six, similar to each other, B B′ B″ .... B^{v}, intercalated between every two tautozonal A, and at an angle of 45°. TESSERAL (ISOMETRIC) SYSTEM.

§ 2.—CHARACTERISTICS OF THE SYSTEMS.

From the above statement of the relations of symmetry in each crystalline system we shall next derive the single faces belonging to each form as well as the most practical method of selecting the axes of the crystal.

For axes we may select any three edges or zone-axes which are formed by three possible faces of the crystal not tautozonal with each other.

We shall, however, on account of the existence of planes of symmetry, so select the axes that, wherever it is possible, they are placed symmetrically to the planes of symmetry, by which we shall at once see that all the faces of a form will take the same numerical indices, but arranged in different orders. We understand by form the combination of all those faces which are symmetrical with each other, according to the planes of symmetry of the given crystal, and which, together, possess the same physical peculiarities.

With regard to the selection of the axes, we only remark that it appears necessary, on theoretical grounds, which were first developed by Frankenstein, so to select the axes that every acute axis-angle shall be greater than 60°, and that every obtuse one shall be less than 120°, which is always possible.

1. TRICLINIC SYSTEM.—No plane of symmetry. The choice of the axes is arbitrary, as also the face 111, by which the plane of the axes is determined—

$$a \gtrless b \gtrless c; \quad \xi \gtrless \eta \gtrless \zeta$$

Five elements are undetermined, two relations and three angles of the axes. Because no plane of symmetry exists, a single face, $h\,k\,l$, (Fig. 20,) with the one parallel to it, constitutes a form. It is only necessary to consider this analogy in the selection of the axes, where there exists a similarity in the angle and in the composition of the faces, with a more highly symmetrical system, as the monoclinic or orthorhombic.

Fig. 20

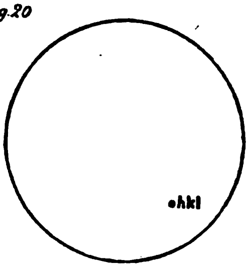
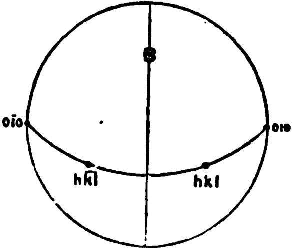


Fig. 21



2. Monoclinic system.—One plane of symmetry, B, (Fig. 21.) We first select this plane as one of the planes of the axes, especially for the plane X Z, so that it takes the symbol 0 1 0. For every face, $h\,k\,l$, a second one is now possible, which, with it, is placed symmetrically with regard to the plane of symmetry 0 1 0, and, therofore, as is easily seen, takes the symbol $h\,k\,l$. These two faces, with those opposite to them, constitute together the general form of the monoclinic system. A zone-axis is determined by every two such pairs of faces, which, as is easily perceived, must lie in the plane of symmetry, because 0 1 0 lies in the zone $[(h\,k\,l)\ (h\,\bar{k}\,l)]$. If two such zone-axes are taken for the axis of X Z, it is at once clear that the angles of the axes will be—

$$X\,Y = \zeta = 90^\circ;\ Y\,Z = \xi = 90^\circ;\ (X\,Z = \eta) \gtrless 90^\circ$$

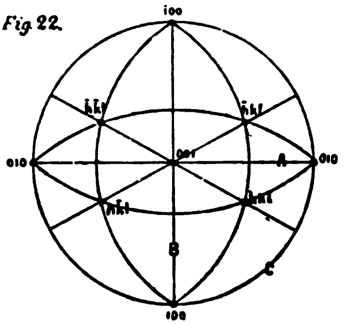
A fourth face gives the sections of the axes $a \gtrless b \gtrless c$, and we have in this system three unknown elements, two ratios, and one angle of the axes.

3. Orthorhombic system.—Three planes of symmetry, A B C, (Fig. 22,) at right angles to one another, which we select for the planes of the axes, with the symbols 1 0 0, 0 1 0, 0 0 1. The three axes will, for this reason, be at right angles to each other, and we have now, by means of a fourth plane, to determine their lengths, so that—

$$a \gtrless b \gtrless c;\ \xi = \eta = \zeta = 90^\circ$$

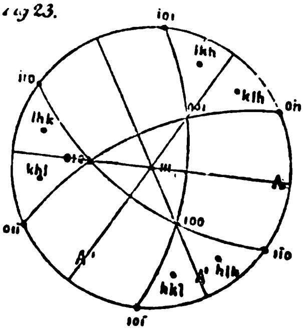
In this system we have, therefore, two unknown elements, $\frac{a}{c}$, $\frac{b}{c}$; the four faces, $h\,k\,l$, $\bar{h}\,k\,l$, $\bar{h}\,\bar{k}\,l$, $h\,\bar{k}\,l$, with their opposites, are similar, so that the general form is an eight-sided rhombic pyramid.

Fig. 22.



With regard to the selection of the three pinacoids, there may be a number of assumptions. Grailich and Lang take $a > b > c$; Schrauf selects, in substances which can be optically examined, 0 0 1, perpendicular to the bisectrix, 1 0 0 and 0 1 0, so that $a > b$; other authors follow no principle, but take the first method of exhibition.

Fig 23.



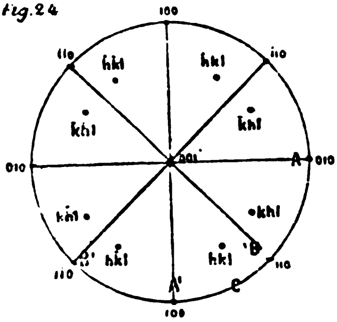
4. **Rhombohedral system.**—Three planes of symmetry, A A′ A″, (Fig. 23,) which are tautozonal, similar, and inclined to each other at an angle of 60°. In this case it is not admissible to select the planes of symmetry for the planes of the axes, because they are tautozonal. In order to observe the symmetry of the method of notation, we select for the planes of the axes three faces of the crystal which are symmetrically situated with regard to the planes of symmetry, and so constitute a form. The faces 1 0 0, 0 1 0, 0 0 1, must be perpendicular to every plane of symmetry, because only one such form, composed of only three faces with their opposites, exists; every other one is composed of six or of two. For the determination of the planes of the axes we select a face, as 1 1 1, which is at right angles to the zone-axis of the planes of symmetry, and is consequently similarly inclined to the three planes of the axes. Therefore—

$$a = b = c; \quad (\xi = \eta = \zeta) \gtrless 90^\circ$$

A single dimension, the angle of the axes, is undetermined.

The three planes of symmetry have the symbols $1\,0\,\bar{1} = \mathrm{A}$; $0\,1\,\bar{1} = \mathrm{A}'$; $\bar{1}\,1\,0 = \mathrm{A}''$. The symbol of each, with the faces tautozonal to the plane of symmetry, which are prisms according to the general notation, thus deviating from usage in the other crystalline systems, is liable to the condition $h + k + l = o$, because the symbol of the zone of symmetry is [1 1 1]. The other forms are scalenohedrons, which is the general form of this system, with six faces, $h\,k\,l$, (Fig. 23,) and their opposites; rhombohedrons, whose faces are perpendicular to every plane of symmetry; the base 1 1 1.

Fig.24



It is plain that the axis-angle ξ is equal to plane-angle of the faces at the vertex of the primitive rhombohedron, (1 0 0).

5. **Tetragonal system.**—Four tautozonal planes of symmetry inclined at an angle of 45° to each other; every alternate two, A A′, B B′, (Fig. 24,) similar; a fifth one, C, perpendicular to these, but not similar. For planes of the axes we select two similar planes of symmetry, which are perpendicular to each other, B A A′, and the single plane of symmetry, C, at

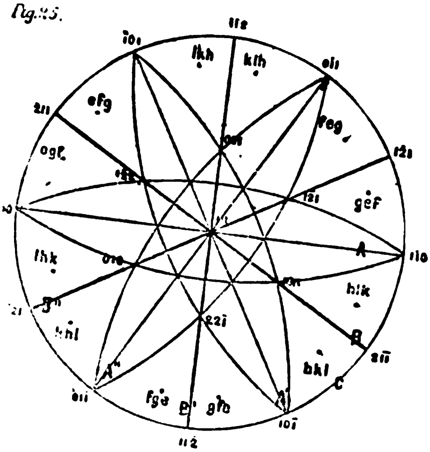
right angles to it, and finally 001 as plane of X Y. For the determination of the lengths of the axes we select a face, 111, perpendicular to one of the intermediate planes of symmetry. We thus have the elements—

$$\xi = \eta = \zeta = 90^\circ;\ (a = b) \gtrless c$$

Thus we have only one unknown quantity, $\frac{a}{c}$. The intermediate planes of symmetry have the symbols 110, $1\bar{1}0$. The most general form is a pyramid of sixteen faces. The similar faces of *h k l* may be seen in Fig. 24.

6. HEXAGONAL SYSTEM.—Seven planes of symmetry, six of which are tautozonal and inclined at an angle of 30°; every other one, A A′ A″, B B′ B″, (Fig. 25,) similar; and the seventh, which is at right angles to them, not similar. We might here have selected for the planes of the axes three planes of symmetry, as C, and two others from the zone, symmetrical to the planes of the axes, but the symmetry of the notation would thus be lost. We select, therefore, as in the rhombohedric system, three alternate faces, of a form perpendicular to the six planes of symmetry, for the planes of the axes 100, 010, 001. We determine the length of the axes, as in the rhombohedric system, by the face 111, which is perpendicular to the axis of the zone of symmetry, by means of which we get, as before—

Fig. 25.



$$a = b = c;\ (\xi = \eta = \zeta) \gtrless 90^\circ$$

Because in particular values of their elements there is no difference between this and the rhombohedric system, they are often united, which is contrary, however, to physical laws.

In this system it is no longer possible to represent the united faces of a form with the same indices with regard to the symbols of the planes of symmetry, as $10\bar{1}$, $01\bar{1}$, $\bar{1}10$, it is for the primary $11\bar{2}$, $\bar{1}2\bar{1}$, $\bar{2}11$; for the secondary planes, B B′ B″, whose sign follows from the zones, we have, for the faces *e f g*, belonging to those lying opposite to *h k l*, the determinative equations—

$$\begin{aligned} e &= -h + 2k + 2l \\ f &= 2h - k + 2l \\ g &= 2h + 2k - l \end{aligned}$$

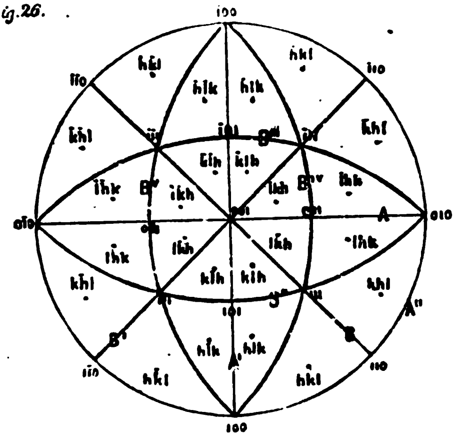
The most general form of this system is a twenty-four-faced pyramid, the half of whose faces, as is seen on Fig. 25, are represented by the symbols *h k l*, and the other half by *e f g*. The forms of this system are generally pyramids of twenty-four faces, two orders of twelve-faced pyramids, whose faces are perpendicular to the principal section, prisms of twelve faces, two orders of six-faced prisms, and the base.

7. **Tesseral (isometric) system.**—Nine planes of symmetry, three of which, A A′ A″, (Fig. 26,) are similar and at right angles to each other; the others tautozonal in pairs, with an A intercalated between each two, B . . . . B^{v}, at an angle of 45° to them. We select the three which are perpendicular to each other for the plane of the axes, and determine the length of the axes by the face 1 1 1, which lies in an intermediate zone; we thus have—

$$a = b = c; \ \xi = \eta = \zeta = 90^{\circ}$$

The five elements are determined.

Fig. 26.



The most general form, *h k l*, consists of forty-eight faces, whose distribution is shown in Fig. 26.

In the previous development only the most general form, *h k l*, has been considered; it is, however, very easy by specializing the symbols, as by an equation of two indices, for instance, or by conditions which can be conceived in the projection, to represent all the forms of a system by the number and signs of the faces.

We wish, for example, the symbol of the faces of the six-sided, the twelve-faced pyramid of the hexagonal system. Their symbols result from the relation of the zones. On the other hand, a simple inspection of the planes of symmetry of this system shows that a face occurring in the zone [(1 1 1) (2 $\bar{1}$ $\bar{1}$)] has on the upper side five similar faces. Thus it results that the symbol of the opposite rhombohedron, similar to the primitive rhombohedron, is ($\bar{1}$ 2 2), according to the formula, (p. 22.) Partial forms have not been included in the above representation, any more than the researches on the symmetry of lines and planes, which will be given in another place.

SECTION III.

OPTICAL RELATIONS OF CRYSTALS.

§ 1.—Double Refraction and Absorption.

It is known that in media of equal density throughout, also in uncrystallized media, a ray of light moves in every direction with the preservation of its condition of vibration; that, further, its velocity of propagation is only dependent on the color of the beam of light, and on a factor which is constant for the entire medium, and not from the direction in which it moves.

If, therefore, a beam of light, under any condition of vibration, enters such an isotrope medium, it can very easily, taking into consideration its angle of incidence, change the direction, and, taking into consideration its color and molecular constants, the velocity of its propagation; the condition of vibration, however, remains constant. The condition of vibration of the beam of light is said to be completely polarized, partially polarized, or unpolarized, according as the whole of the light or only part of it vibrates in a constant path, or this course takes in an infinitely short space every possible transversal position. In the first case, where the whole light has a constant path of vibration, we say again that the light is polarized in a straight line, circularly, or elliptically, according as the path of oscillation is a straight line, perpendicular to the direction of propagation, a circle, or an ellipse. The movement of the light in an isotrope medium is, therefore, dependent on that of the incident light, the angle of incidence, and a molecular constant.

In a crystallized medium, in which the density can be supposed variable with the direction, only two beams of light of a determined velocity of propagation for each color, and determined direction of vibration, can, in general, be propagated in any determined direction; on the contrary, a beam of light entering a crystalline medium will not only be deviated from its direction, but separated into two divergent beams, each one of which, according to its direction in the crystal, will have variable velocities of propagation and direction of vibration.

Just as the intensity of the light is weakened by its passage through an isotrope medium, and has different strengths for different colors, so is it the case with crystalline media, only here the unequal absorption for different colors depends on the direction in the crystal; the same is here true as of the manner of vibration and the velocity of propagation. The same direction in a crystal corresponds thus to two determined beams with determined velocities of propagation, direction of vibration, and absorption; and a ray of light entering a crystal is divided into two beams of determined but different directions of propagation, velocities, directions of vibration, and absorption.

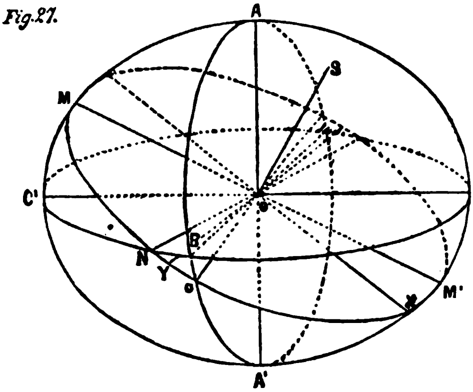
§ 2.—THE ELLIPSOID OF POLARIZATION.

The law according to which the whole movement of light in a crystal is determined can, so far as is necessary for our present purpose, be ennunciated as follows:

In every crystal an ellipsoid with three axes can be constructed in such a way that the velocity of propagation and the direction of vibration of the two rays of light, which can move in a fixed direction in a crystal, may be determined by the major and minor axes of the ellipse, which are formed when, from the center of the ellipsoid, a plane is passed perpendicular to the given direction of propagation of both of the beams, and this prolonged to its section with the ellipse.

Let *o* A, *o* B, *o* C, (Fig. 27,) be the principal axes of the ellipsoid, at right angles to each other; S *o*, the direction, passing through the center, in which the two beams of light should move. Let us pass through O a plane perpendicular to *o* S, which cuts the ellipsoid in the points M N *o* M′, which points belong to an ellipse whose major and minor half-axes are *o* X and *o* Y; of these two beams, propagated in the direction S *o*, the one has the direction of vibration *o* X and the velocity of propagation $\frac{1}{0}$, and the other O Y and $\frac{1}{0}$.

Fig. 27.



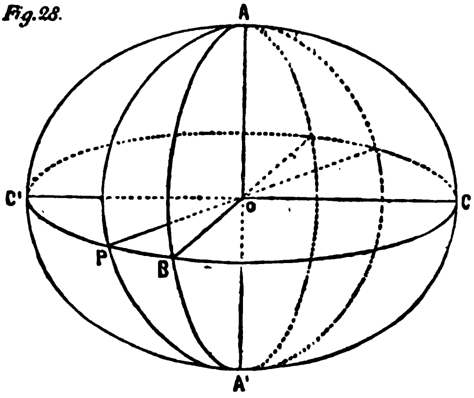
The situation and the length of the principal axis of this ellipsoid are, in general, different for every color. The absorption of the light in any direction can also be determined from the principal axis. With the co-efficient of absorption of the principal axis we can again construct an ellipsoid whose axes correspond to those of the ellipsoid of polarization. The co-efficient of absorption for the two rays of light corresponding to a direction will be determined sometimes by the ellipse-section and sometimes by the absorption-ellipsoid; the major and minor axes of this ellipse, it is true, do not coincide exactly, but they do approximatively with those of the direction of vibration.

In the most general case, which we shall first discuss, the three axes of the ellipsoid are of unequal lengths; they will be called axes of polarization or of elasticity; by the last is also specially understood their reciprocal lengths, as—

$$a = \frac{1}{o\,A};\ b = \frac{1}{o\,B};\ c = \frac{1}{o\,C}$$

in which $a > b > c$ is chosen; hence the distances *o* A, *o* B, *o* C, are themselves proportional to the principal quotient of refraction.

Fig. 28.

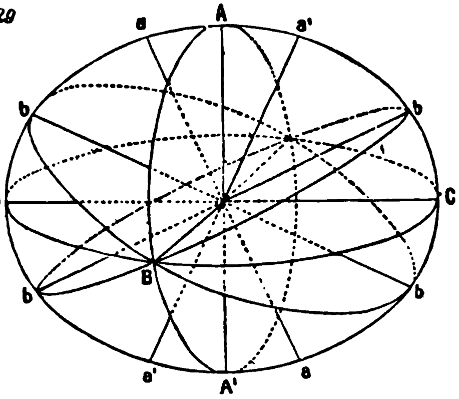


A plane of the axes containing two axes of elasticity is called the principal section, and is perpendicular to the third axis.

A plane parallel to one axis, as *o* C, (Fig. 28,) cuts the ellipsoid in an ellipse, C P C′, one axis of which coincides with the known axis of elasticity, and the other axis, *o* P, is perpendicular to it in the principal section A B *o*.

A plane M N *o*, (Fig. 27,) inclined to all three of the axes of elasticity, cuts the ellipsoid in an ellipse, whose axes are not parallel to any of the axes of elasticity. In general, $a > b > c$ is true in the principal section A *o* C, (Fig. 29,) whenever there is a radius, O *b*, whose length is equal to the middle axis of elasticity, O B. If a plane, B *o b*, is passed through this last and this radius, their section of the ellipsoid is a circle; the normal *o a* to this circle-face lies in the principal section of the largest and smallest axes of elasticity, *o* A C, and is called an *optical axis*. This ellipsoid, which has three axes, has two optical axes, *o a* and *o a′*, (Fig. 29,) which are in the planes of the greatest and smallest axes of elasticity, and are situated symmetrically with regard to both.

Fig. 29



The optical axes form with each other two supplementary angles, an acute, 2 Y *a*, and an obtuse, 2 Y *o*, so that $2\,Y\,a = 180^\circ - 2\,Y\,o$, which are equally divided by the axes A and C; that axis which divides the acute-angle axis is called the ***first middle line***, ***(bisectrix,)*** and the one which divides the obtuse-angle axis is called the ***second middle line***, so that two cases are again possible:

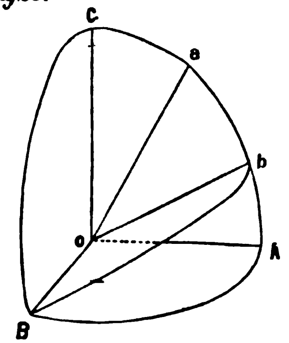
First middle line $\underset{-}{a}$, second middle line *c*: negative crystal.

First middle line $\underset{+}{c}$, second middle line *a*: positive crystal.

The first case is assumed in Fig. 29. Fig. 30 shows a sketch of the last.

According as the nature of double refraction consists in a difference of the velocity of propagation and of the direction of vibration of the two beams of light capable of being propagated in the same direction, it is at once clear that the double refraction must disappear along the optical axes. The plane normal to a beam of light, that is, the one which propagates itself in the direction of an optical axis, cuts the ellipsoid in a circle; the velocities of propagation of the beams of light given by two radii are equal to each other; the directions of vibration are undetermined, *i. e.*, remain unchanged, as they were before their entrance into the crystalline medium.

Fig. 30.



If a crystal has a plane of symmetry, it must coincide with a principal section of the ellipsoid for every color, because an ellipsoid with three axes is symmetrical only in its principal sections; this coincidence must not, however, occur in the same principal section for every color; thus, for red light, *b c*, and for blue light, *a c*, may fall in the plane of symmetry. If two axes of elasticity of the same ellipsoid are equal, their principal section will be a circle, and the two axes become reduced to one; if, for instance, the third axis of elasticity is perpendicular to this principal section, the ellipsoid is an ellipsoid of rotation. The sections of such an ellipsoid, with a plane, are either *perpendicular* to the optical axis, section a circle, no double refraction, direction of vibration undetermined; or *parallel* to the optical axis, section an ellipse, one axis of which is the optical axis, the other has a constant value, which is that of the axis of elasticity originating in the circle; or *inclined* to the optical axis, section an ellipse, whose axes are inclined to the optical axes. Ellipsoids with a single axis are of two kinds, lengthened or flattened, according as—

$b = c$; $\underset{-}{a}$ the optical axis; negative crystal, (Fig. 31.)

$a = b$; $\underset{+}{c}$ the optical axis; positive crystal, (Fig. 32.)

Fig. 31.

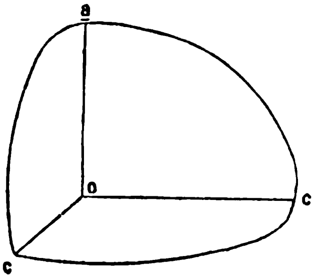
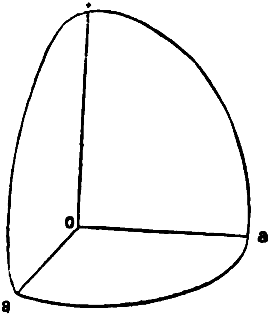


Fig. 32.



If all three of the axes of elasticity of the ellipsoid are equal to each other, it becomes a sphere; every section by a plane will be a circle; all the axes of such a circle will be equal to each other. Such a crystal is monorefringent, and has no determined direction of vibration, that is to say, the direction of vibration of the beam of light entering the crystal remains the same.

As has been already mentioned above, the relations of absorption in the whole crystal can be determined if they are given for the three axes of elasticity. If we construct an ellipsoid from the three principal absorption-constants (for a determined color) as axes, we find, exactly as in the ellipsoid of polarization, the amount of absorption for a given direction in the crystal by passing a normal plane and determining the axes of the ellipse-section so produced.

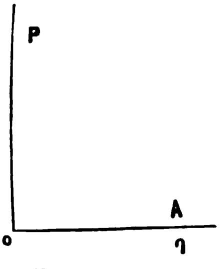
§ 3.—OPTICAL RELATIONS OF PLANE PLATES WHOSE SIDES ARE PARALLEL.

We shall first consider the relations of plane plates of crystals whose sides are parallel, in straight-lined parallel light and perpendicular incidence. Let the entering beam of parallel straight-lined light polarized by any means, such as a nichol prism, heropathite, or a plate of tourmaline, fall perpendicularly upon a plane plate of the crystal whose sides are parallel. In consequence of its perpendicular incidence, for we can treat parallel light always so, the beam of light enters the crystal without deviation; in this defined direction only two beams, whose direction of vibration is determined according to § 2 of this section, can transmit themselves in the crystal, because we bring the plane of the plates, which is perpendicular to the path of the beam of light, into the section of the ellipsoid of polarization.

The entering beam of light must now be divided, according to these two lines at right angles to each other, into two component parts, which then follow the same path entirely through the crystal; passing out of it, however, they fall upon a second polarizing arrangement, the analyzer, which, as the polarizer, allows the vibrating light to pass only in a given direction. Here the two beams of light are divided in such a way that only that component which falls in the plane of vibration of the analyzer comes out of it; finally, both these components, polarized in straight lines, have similar directions of vibration, and the same path, and for this reason unite in a straight polarized beam of light, with the same direction of vibration as component and analyzer.

We suppose that both the polarizer and the analyzer are so placed that their directions of vibration are parallel to each other, which position is once for all determined. Let us now turn the crystal-plate in its own plane until its directions of vibration come together, the one, $o\xi$, (Fig. 33,) with o P of the polarizer, the other, $o\eta$, with o A of the analyzer, and we have the following result:

Fig. 33.



Straight-lined polarized light comes from the polarizer in the direction of vibrating light, o P. By its entrance into the crystal it will be divided in the direction $o\xi$ and $o\eta$, which is its direction of vibration; thus no component escapes, especially in the direction $o\eta$, but the beam passes through the plate in the direction $o\xi$, and passes out of it with the direction of vibration $o\xi$, falls upon the analyzer, is here divided into two components, of which only the parallel one, o A, is allowed to pass parallel to o A; however, $o\xi$ gives out no component, which means that in this case no light whatever comes through the analyzer.

We see also that any crystal-plate with parallel planes appears dark when placed between polarizers which are at right angles to each other, as soon as its direction of vibration coincides with that of the analyzer and polarizer.

In order to observe the absorption, we have only, when the plate is in the position of darkness, to take away the analyzer or the polarizer. In this case only the color corresponding to the one direction of vibration of the plate appears. This occurrence thus shows itself entirely analogous to the previous one.

It is at once clear that a plate perpendicular to an optical axis appears dark in every position of the crossed polarizers. Respecting the relations of a plate with parallel sides between polarizers in a cone of monochromatic light, we only remark that optical axes are shown by a system of very nearly concentric rings, through whose center a dark, straight or hyperbolic beam, or a dark cross, appears. The appearance of these in white light will be described for some of the systems.

§ 4.—Optical Relations in each Crystalline System.

As has already been mentioned above, the position of the principal optical section and the value of the axes of elasticity are different for different colors. A coincidence takes place only in the case of the existence of one or more planes of symmetry, because such a one must always be a principal optical section.

1. Triclinic system.—No plane of symmetry. The position of the ellipsoid of polarization for the different colors cannot be determined *a priori;* the axes of elasticity are inclined to the axes of the crystal; all the principal optical sections are dispersed, that is, have a different position for every color. In general, the dispersion of the principal section, both here and in the following crystalline systems, is small, and seldom goes beyond one or two degrees. The appearances of color in plane plates with parallel sides, which allow the optical axes to be distinguished, are in monochromatic light as follows: A plate perpendicular to the bisectrix shows, when the polarizers are crossed, a black cross, (Fig. 34,) upon one arm of which the elliptical rings of the optical axes appear surrounded by lemniscates if the principal axes of the plate coincide with those of the polarizer; when hyperbolæ (Fig. 35) pass through the rings of the axes, the principal sections of the plate are inclined 45° to the polarizer; in white light the rings of some colors

Fig. 34.

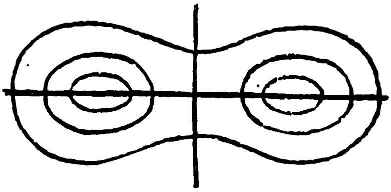
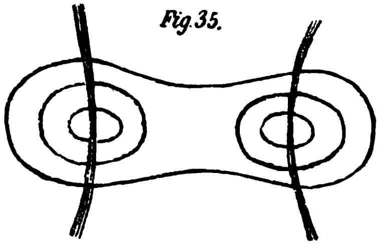


Fig. 35.



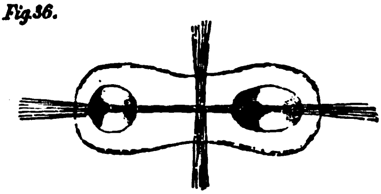
appear superposed; on account of the dispersion of the principal section, both of the two images of the axes, and also the arrangement of the colors in both of them, will be unsymmetrical with regard to the principal section, which is marked by a somewhat faint and black beam. The detail of this image of the axes is most simply described by saying that a union of the cases of dispersion, met with in variable intensity in the following system of crystallization, is to be here observed.

2. MONOCLINIC SYSTEM.—One plane of symmetry. A principal optical section of every color must coincide with the plane of symmetry, so an axis of elasticity of every color must coincide with the axes of the crystal *o* Y, perpendicular to the plane of symmetry. The two other principal sections, as also the two axes of elasticity lying in the plane of symmetry, are dispersive for the different colors. There are here three possible cases:

First. The principal section *a c*, containing the optical axes of a color, coincides with the plane of symmetry, *inclined dispersion*, (*dispersion inclinée* of Descloiseaux.) The general case is, that the analogous principal sections have for all colors very nearly the same position; in this case the optical axes, for all the colors, lie in the plane of symmetry; the image of a plate perpendicular to a bisectrix, (convergent light,) on account of the correspondence of the direction of vibration of the plate and the polarizer, is symmetrical with respect to the black beam joining the image of the axes, (Fig. 36.)

Secondly. The principal section of the axes is perpendicular to the plane of symmetry; the bisectrix lies in the plane of symmetry, *horizontal dispersion*, (*dispersion horizontale* of Descloiseaux.) In this case *c b* for positive crystals, and *a b* for negative crystals, coincide with the plane of symmetry.

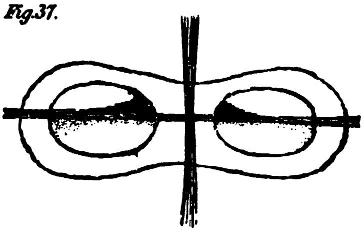
Fig. 36.



If the general case of the approximate coincidence of similar principal sections for different colors is selected, we see that here the planes of the optical axes are dispersive. The image of the axis appears symmetrical with respect to a beam perpendicular to the line of the optical axes, (Fig. 37.)

Thirdly. The section of the axes *a c* and the bisectrix are perpendicular to the plane of symmetry; the principal section *a b* for positive, and *c b* for negative crystals, coincide, therefore, with the plane of symmetry; *cross-wise dispersion*, (*dispersion croisée* of Descloiseaux.) The planes of the axes are dispersive.

Fig. 37.

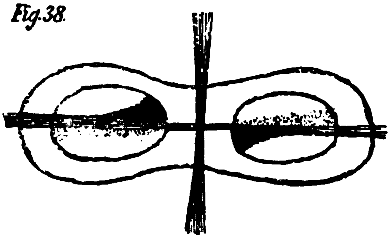


Under the same supposition as before, the image of the axes will not be symmetrical with regard to any line;

the planes of the axes appear round the normal to the plate, (second crystallographic axes, *o* Y, bisecting,) dispersed in the shape of a fan, (Fig. 38.)

3. ORTHORHOMBIC SYSTEM.—Three unequal planes of symmetry at right angles to each other. Every plane of symmetry must coincide with a principal section; here the position of the principal optical section is completely determined, and only the value and position of the axes of elasticity are undetermined. In most cases the similar principal sections of all colors coincide, as also do the axes of elasticity *a*, *b*, *c*.

Fig. 38.



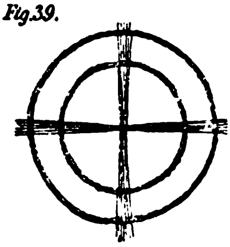
The image of the axes, according to the former suppositions, is symmetrical with regard to the two black beams; it appears also in white light, similar to Fig. 34, but in this case the black ellipses are replaced with color. The principal optical section is not dispersive; the optical axes, however, are; that is, the angle of the axes is different for different colors, as in both the previous systems.

4. RHOMBOHEDRIC SYSTEM.—Three tautogonal and similar planes of symmetry, inclined at an angle of 60°. Every one of these must be a principal section of the ellipsoid; this is only possible if all these zones belonging to the section of the ellipsoid are equal to each other; that is, it is an ellipsoid of rotation; the principal section perpendicular to the plane of symmetry is a circle; the axis of the zone of symmetry is the optical axis of all the colors. Here, as we have already mentioned, two cases are possible, positive or negative crystals, according as $b = c$ or $a = b$.

If we again make the supposition that the similar axes of elasticity coincide for all colors, we get, as the image of a plate cut perpendicular to the optical axis between two crossed polarizers, a black cross with concentric colored rings, (Fig. 39.)

5. TETRAGONAL SYSTEM.—Five planes of symmetry, four of which are inclined 45° to each other, every alternate one being similar, the fifth perpendicular to the four others.

Fig. 39.



A principal optical section is parallel to this last, as the hypothetical plane of symmetry 0 0 1. All its perpendicular ellipsoid sections must be equal to each other, because in this zone four planes of symmetry exist, all of which must be principal sections of the ellipsoid. The tetragonal system, therefore, is optically exactly like the rhombohedral.

6. HEXAGONAL SYSTEM.—Seven planes of symmetry, six tautogonal inclined 30°, every alternate three similar, one perpendicular to them. This last, taken as a principal section, makes, as in the two previous

systems, all sections perpendicular to it similar, on account of the symmetry according to the six tautozonal planes of symmetry; on this account, therefore, having the same optical relations. The base 111 is perpendicular to the optical axis.

7. TESSERAL (ISOMETRIC) SYSTEM.—Nine planes of symmetry, three perpendicular to each other and similar, the other six intercalated tautozonally at 45° between each two of the first.

If we take the first three planes of symmetry parallel to the three principal sections, it results immediately, from the existence of the other planes of symmetry, that the ellipsoid of polarization must be a sphere whose radius is different for different colors. A sphere has only circular sections; therefore, simple refraction is produced in all directions.

We have above considered only the cases where the similar principal sections of all colors very nearly coincided; the exceptions to this law are really very rare, and present no difficulties. Observation by means of monochromatic glasses or sources of light always allows a very quick orientation.

We have also in the above description left out crystals with one axis, which polarize circularly, because they, in spite of the greatest theoretical differences, can practically be regarded exactly as the other monoaxial crystals, with the exception of the image of the axis, which inside of the rings shows that the black cross is replaced by a uniform color, which is dependent on the thickness of the plate.

It is now no longer necessary to describe the special behavior of sections of different crystals with respect to the orientation of their direction of vibration. The orientation of the ellipsoid, with regard to the axes of the crystal and their respective planes of symmetry, is given above; if, therefore, the crystallographic orientation of a plate is known, the kind of section in the ellipsoid and the directions of vibration can be at once determined. Inversely, the experimentally easily-determined position of the direction of vibration of a section of known crystallographic orientation gives a starting-point for the determination of the system.

Reviewing the method of development of the foregoing sketch, we see, as the starting-point, the law of experience, that by the selection of a certain method of representation, the symbols of all faces and zones consist of whole numbers, whose relations with one another are therefore rational numbers.

From the rationality of these numbers follows, in a way which we could only briefly dwell upon, that only such groupings of faces are possible which belong to one of the seven different kinds of symmetry, the seven systems of crystallization. From the general law of the movement of light in crystals resulted the ellipsoid of polarization for the derivation of all special rules. The relations of symmetry of the separate systems of crystallization allow us to discover in a very simple manner the nature of the ellipsoid of polarization, and with it the optical characters of every system, with which we have completed the object of this memoir.

METEOROLOGY IN RUSSIA.

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The first meteorological observations in Russia were made about the middle of the eighteenth century. The points of observation were few, scattered irregularly over the country, with very different methods and instruments. About the end of the last century attention was directed to that distant but highly interesting land, Siberia. The natural history of the country having been studied by Lepechin, Pallas, Gmelin, and others, the necessity of investigating its climate was also felt. Some efforts were made in this direction; thermometers were distributed, but the result was not encouraging, and we know next to nothing relative to these first Siberian observations. Even at the beginning of the nineteenth century the necessity of the study of meteorology was not generally recognized in Russia, and only as late as about 1820 were the number of points of observation increased. Between the years 1820 and 1835 meteorological observations were made in about thirty places, generally by private individuals, without any unity of plan, and often with imperfect instruments. Probably even many of the journals kept at that time were lost to science, for every observer worked by himself, and had generally no communication with each other and the leading savans of the time.

The great impulse given to the study of magnetism in 1828 had an influence on meteorology. In that year the "magnetische verein" was founded in Germany, and its president, Baron Humboldt, made great efforts to induce the Russian government to establish magnetical observations in its dominions. The Academy of Sciences warmly seconded this effort, and in consequence magnetical observatories were established at St. Petersburg, Kasan, Nicolajef, Sitka, and Pekin, and sometime afterward at Catherinenburg, (Ural,) Barnaul, (West Siberia,) and the mines of Nertschinsk, (East Siberia.)

In 1833 Kupfer presented a plan of reorganization of the magnetical observatories, so as to include meteorology. He was supported by the minister of finance and the chief of the engineers of mines, K. W. Tchefkine. This plan was approved by the Emperor Nicholas, and, like the system of magnetical observations, was placed under supervision of the department of mines, with its center at St. Petersburg. Magnetical and hourly observations were to be made at the following places: St. Petersburg, Barnaul, Catherinenburg, and Nertschinsk, and, in addition, meteorological observations at Bogoslovlsk and Zlatouste, (Ural) and Lugan, (Southern Russia.) The observations were to be published at the expense of the department of mines; and Kupfer was appointed director of the system. All this was accomplished between 1835 and 1841. The observatories, however, of Nicolajef, Sitka, and Pekin were not under Kupfer's direction, nor was that of Tiflis, founded in 1844. A yearly publication, under the title of "Annuaire magnetique et meteorologique," was devoted to the meteorological observations of the stations of the department of mines, as also to those of Sitka, Pekin, and Tiflis.

In 1849 the Russian central physical observatory was founded. No change was made in the position of the principal points, but the observatory entered in communication with private observers, furnished them with good compared instruments, and published the daily means of their observations, as also those of the government stations, in a quarterly volume named "Correspondence meteorologique." The publication of the hourly observations of the principal stations continued under the title of "Annales de l'observatoire physique central." Thus for the first time a general system of meteorological observations was founded in Russia. New observers volunteered to assist in the work, and public institutions took part in this movement. The department of public lands furnished good instruments to its schools of agriculture, and some of their observations are very valuable. Mr. Wesselovsky stimulated their zeal and began at the same time to collect the meteorological journals of private observers, for a general work on the climate of Russia. Many journals were thus saved from oblivion, and the results of many private exertions were placed in the reach of the scientific world.

His "Climate of Russia" appeared in 1857, and, being still the most extensive and complete work on this subject, I may be allowed to give an account of its contents:

The author having the intention of publishing a strictly climatological work, with a view to apply his researches to statistics, and especially to the influence of climate on man, unfortunately excluded all that relates to the pressure of the air. Extensive tables are, however, given of the mean temperature for one hundred and forty-seven stations, in which number twenty-six are for Siberia and Russian America, with a clear exposition of the principal features of the distribution of the temperature, and an appendix on the heating power of the sun's rays and the temperature of the soil. A table is also given of the freezing and opening of one hundred and forty rivers and lakes. In this respect the compiler, Mr. Wesselovsky, was favored by the particular position of the rivers of Russia, and the attention always paid to this subject. Yet the collection of much of the datawas due to his strenuous exertions. We are presented with an unbroken record of the time of freezing and opening of the Neva, at St. Petersburg, reaching back to 1706, that is, for one hundred and sixty-seven years, and records of from eighty to one hundred years for about ten other places. The most important part of the work relates to the winds. Wesselovsky was the first to prove that in southern Russia the winds are easterly in autumn and winter, while in the center and northern part of the country they are from the southwest at this time of year, the same as in England and Germany. These relations of the wind to the seasons were exposed with the greatest clearness, and the new data since collected have only confirmed Wesselovsky's views; as I shall afterwards show, surprising as it may appear, the anemology of Russia and Siberia is even now misunderstood, especially by foreign meterologists. A chapter on vapor, clouds, rain, and hail follows. The observations were very few, while these phenomena, being local, can only be well studied when we have a great number of observations. The last chapter of the work is also of great importance; it treats of the changes of climate, and presents conclusive evidence that appreciable changes have not taken place in historical times. By consulting the classical authors, Wesselovsky shows that the general opinion that the climate of Southern Russia has become milder has no foundation. If Ovid, banished to the countries of the lower Danube, is astonished at the rigor of the climate, this is quite natural for a southerner. The Danube froze at that time as it freezes now, at least in its lower parts. The facts related by Herodotus relative to Scythia are still more important. At that time, as now, rains and thunder-storms were frequent in summer, and this was new to a Greek, accustomed as he was to a rainless summer in his own country, while the rains of winter were less abundant in Scythia than on the shores of the Mediterranean.

Herodotus also tells us that Southern Russia was a steppe, (1) at his time, as it is now, and probably has been during the whole of the present geological period.

The freezing and opening of rivers affords the author another proof that the climate has not changed in this respect since the beginning of the eighteenth century; at least that the time when the temperature is below the freezing-point is now the same as before. There is certainly a great variation in this respect in single years, and even in periods of from ten to twenty years. But nothing indicates a permanent change of climate. Cold years are followed by warm ones, and vice versa. If we take periods of thirty years at St. Petersburg, we have as follows:

Years.	Freezing.	Opening.	Days frozen.
	November.	*April.*	
1724–53	25.7	22.6	148.7
1754–1783	29.7	20.6	143.4
1784–1813	22.0	23.2	153.2
1814–1843	26.9	19.5	144.6

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(1) Jreeles' region, prarie.

If we take periods of sixty years the difference is still less.

Years.	Freezing.	Days frozen.
	November.	
1724–1783	27.4	145.1
1794–1853	24.5	147-9

The Düna at Riga, where we have some observations made in the sixteenth century, gives a similar result. The average time of the opening of the river, in forty years of the sixteenth century, was April 9.6; in ninety-one years of the eighteenth century, it was April 7.2; in fifty-four years of the nineteenth century was 8.4. The Dwina at Archangel and the Dnepr at Kiev also show very slight differences between this century and the last.

The second part of Wesselovski's work contains extensive tables invaluable to the meteorologists. The mean temperature, the number of rainy days, and amount of fallen water, are given for every month of every year, so far as he could obtain the data. This collection of observations is extremely important for the study of the non-periodic variations of the meterological elements. The freezing and opening of rivers is given for every year separately, and it is much to be desired that such tables should be obtained for other countries. As yet they are very few in number, and no country of any considerable extent has tables of this kind comparable to those given by Wesselovsky.

About the year 1850 the geographical society of Russia began to collect information on the climate of the empire. No society or institution has the means of enlisting the co-operation of so many meterological observers as this society, it being widely known throughout the country, and having a great number of correspondents. It was thought necessary to collect topographical descriptions of different places, as a foundation of local climate, as well as observations of the periodical phenomena. In 1857 a meterological committee of the society recommended the establishment of a periodical devoted to the meteorology of Russia, as well as to allied branches of this science. The society adopted this recommendation, and the journal known as the "Repertorium für Meteorologie" was established under the directorship of Kämtz from 1859 to 1863. Three volumes appeared and were highly valued by men of science. The most important contribution was by Kämtz, "Klima der südrussischen Steppen." About this time, especially since 1860, a general belief was entertained that the system of meteorological observations established in Russia had proved a failure, the money given by the government had been expended to little purpose, that the whole system required reorganization. As is generally found in such cases, there was considerable truth, and also a great deal of exaggeration in this opinion. The enormous extent of country over which the meteorological stations were scattered prevented their frequent revision, a condition necessary to the successful working of a meteorological system. The instruments of the stations were not frequently enough compared with the standards. All this certainly rendered the observations less valuable than they would otherwise have been, yet the location of the observatories, especially those of Barnaul and of Nertschinsk, in a country the study of which is especially important to meteorology, rendered even second-rate observations valuable. On the other hand, the liberality of the Russian government in publishing the observations in full was of great use to science. It is only within the last ten or fifteen years that we have learned the great value of actual observations, while in former times monthly means were thought quite sufficient. The Russian publications were not valued as highly as they merited, because they were in advance of their time, and we are now able to say that the system of observations and publications established by the Russian government was not a failure, but rendered good service to science.

About the year 1865 efforts were made to extend the meleorological observations and establish a system of telegraphic bulletins. The ministers of the navy and public instruction took an interest in the enterprise, but the practical result was next to nothing.

After the death of Kupfer, Kämtz was nominated director of the physical observatory. Extensive reforms in the organization of the meteorological system began at this time, and were continued by his successor, Dr. H. Wild. The physical observatory is now placed under the authority of the academy of sciences, and that body has the choice of its director. A new set of instruments was ordered to be made, compared at the observatory, and sent to the different stations. The centigrade scale for the thermometer, and metrical divisions for the barometer, and rain-gauge have been in use since 1870, so that nearly the whole continent of Europe have the same measures for the meteorological instruments. The German meteorological system, directed by Dové, alone forms an exception, having the Reaumur scale for the thermometer and the old French measures for barometer and rain-gauge. The form of publication was also changed; hourly observations had ceased since 1868 except at Tiflis, and it was decided to publish the observations made thrice a day, without any difference between stations maintained by the government and those of private observers. The first Annales published in this way were those of 1865; those of 1866, 1867, and 1868 were in the same form, while the observations of 1870 and 1871, made after the new system, are already published, and those of 1872 in active preparation. No meteorological system in Europe has a publication of the same importance, for it must be repeated that original data are especially necessary in the present condition of science. These data must be printed to render them most useful, and also to place them within reach of every student of meteorology. This is generally recognized by all men of science in Europe, and they would establish a similar system of publications if only the money could be procured to defray the expense. In the present position of central and western Europe this is very difficult, as the expenditure for military operations has increased to the utmost, and the governments are very economical in their appropriations for scientific purposes. Happily Russia is now in a better condition, and can afford to devote more means to the cultivation of science and other truly useful purposes.

We have seen that the system of publication adapted in Russia is commendable. The other points of the system are far from being as good. (1.) There are too few stations in many parts of the country, especially in the North and in Siberia. (2.) The stations are too seldom visited, and their instruments compared with standards. (3.) The practical applications of meteorology are lost sight of by the physical observatory. The inconvenience arising from the too great distance of the stations from the central observatory has already been recognized. Wild proposed to have branch central observatories in the university towns, and some other principal cities of the empire, the director of which would each have the supervision of a part of the country. The directors of these observatories would inspect the stations as often as possible, and compare their instrument with standards. The central physical observatory at St. Petersburg would have to determine as to the system of observation and registration to be adopted, and to reduce, discuss, and publish the observations from all parts of Russia. It was proposed to have such branch observatories in Moscow, Kasan, Charkof, Kiev, Odessa, Dorpat, Warsaw, and Helsingfors, Wilna, Tiflis, Irkutsk, Taschkend, and Pekin which would complete the system. At Tiflis the system is in operation, as the director of the observatory at this place has the control of the observations made in the Caucasian provinces, inspects their instruments, &c., and sends their observations, after discussion, to Petersburg to be published. Unfortunately this system of centres could not be fully realized for want of means. The principal reason why the meteorological system of Russia, so excellent in many respects, cannot be completed as was intended, is that meteorology has not been practically applied in Russia, and the observatory has not interested the people at large in its principles and importance. This is true to such an extent that very few, even in St. Petersburg, have an idea of the existence of a central physical observatory. Indeed the notion is prevalent that meteorology is a part of the operations of the astronomical observatory of Pulkowa; this being the case, a much less number of observers are willing to do the work imposed by the regulations of the government, and for which they are not paid, because they do not have a definite notion of what becomes of their work when it is sent to St. Petersburg. Some of the former observers have refused to undertake the greater amount of labor necessary in carrying out the new system, and certainly there are many of these who are quite unknown to men of science, whose laborious efforts have in a great measure been lost for want of proper instructions of what and how to observe. A second drawback experienced in carrying on this system is the difficulty, to which we have before alluded, of getting the additional grant of public money so necessary to the further progress of meteorology as well as to its practical application. So far from interfering with the progress of pure science, the practical applications, in extending the number of observations and increasing the number of men interested in science, can only conduct to new discoveries.

In speaking of practical appliances I, of course, refer to the system of weather telegrams and predictions so extensively used at present in the United States.

As some of the general movements of the atmosphere have been determined, and it is known that in Russia the storms move from west to east, as they generally do in the middle latitudes of the globe, we are in a very favorable position for the prediction of the weather, much more so than those in Western Europe, and scarcely less than in the United States. As a great many meteorological stations exist in the west of Europe, it is easy to obtain telegraphic communications relative to the weather from them for the mere expense of the telegrams. The Norwegian meteorological institute has already established forewarnings of storms, and it would be only necessary to establish telegraphic lines to the shores of the Arctic and White Seas, for the benefit of the shipping and fisheries of these regions. The western part of Russia, with the Arctic, White, Baltic, and Black Seas, would thus mainly depend on intelligence received from abroad, while the railroad officials and travelers inland could be warned of the approach of storms of snow and rain by the intelligence received from Western Russia. The delays on the railroads and the great loss of life which frequently occur on ordinary roads could thus to a great extent be prevented. After the climatical features of Russia have been sufficiently studied, agriculture itself would profit by the warnings of heavy rains and thunder-storms predicted in advance; they would be prepared for and lose a part of their baleful influence. Within the three last years the geographical society has again busily occupied itself in promoting the study of meteorology in Russia, and the success of the first two years of this work is very encouraging. The geographical society did not, however, wish to interfere with the business of the physical observatory, yet the inability of this institution to perform all the labor was too clear to be ignored. It was proposed to elect a meteorological commission from among the members of the society. This commission was elected in the beginning of the year 1870, and discharges the duties of meteorological societies in other countries; that is, it furnishes the theoretical and practical propositions of the science.

A general system of rains and thunder-storm observations was commenced, in the prosecution of which the society was much favored by its extensive correspondence throughout the country. Circulars explaining the necessity and mode of observations were sent to the corresponding members, to various schools, to the presidents of the district assemblies, &c. A cheap rain-gauge was also adopted, of which the principle is simple and its use easy to understand. Of these there were about sixty new observers in the spring of 1871, while all the necessary preparations were not completed until the autumn of 1870. A year later the number of observers had increased to about two hundred, and this state of things continued to be very promising up to the time when I left St. Petersburg, in December, 1872. The success of this effort proves that it is not difficult to find many persons willing to work for science, even if an immediate practical result is not expected, provided only that the final utility of the results is properly explained.

To obtain this very desirable result it was necessary to publish and send to the observers papers on meteorological subjects, which would tend to awaken and sustain their interest in the subject. This was done by the geographical society in Nos. 1 and 5 of its "iswastia" which contained papers of this kind, copies of which were sent to all observers, and generally distributed. Being secretary of the meteorological commission, I was charged with the duty of drawing up the result of the first year of observation, from December, 1870, to November, 1871. The results obtained were better than could have been expected from the variable nature of aqueous precipitation. It was even possible from the data to draw isohyetal lines, the first ever attempted in Russia, for the months of May, July, August, and September, 1871. It was found easier to draw isohyetal lines for one single month than for means of different years in different places. As to the thunder-storms, it was less easy to obtain general results from the few observations made in 1871; maps could not be drawn from them. On the other hand, the results for the direction of thunder-storms and the hours at which they occurred were satisfactory. The most prevailing direction was from southwest, next from south,southeast, west and northwest, while from the other directions their appearance was very seldom indeed. The hour of the most frequent occurrence of thunder-storms was about 3 p. m. At some stations situated from one hundred to two hundred and fifty miles east of the Ural mountains a second hour of maximum occurrence existed late in the evening. As the storms move from W. to E. these latter ones evidently originated in the Ural mountains, where it is known that frequent and very violent thunder-storms occur in summer, and moving eastward arrived later in the day. A similar feature could be noticed in the southwestern group, Kiev, Podolia, and Volhynia. They are to the east of the Karpathians, and the thunder-storms from that quarter reach them in the night.

The geographical society further decided to devote a volume of its

("Sapiski") memoirs entirely to meteorology, especially to investigations relative to the climate of Russia. The reason of this decision was the desire that was felt to have this subject thoroughly investigated, so as to produce a work on the level of the science of our time, as Wesselovski was of that of sixteen years before. It was hoped that the members of the meteorological commission would contribute to the desired result, which could only be attained by the united efforts of many laborers. The plan of periodical publication of the society "isvastia" was not well adapted to meteorological works of great extent, being principally devoted to the progress of geography. The Siberian section of the geographical society at Irkutsk has also established a meteorological commission, with the same powers as that of St. Petersburg. Many observations made in Eastern Siberia are reduced and discussed there, and much progress in the science may be expected from that quarter. There are few countries so interesting to meteorology and yet so little known as Eastern Siberia. It includes the meteorological pole of winter—that is the coldest region in this season—and besides embraces an enormous extent of country, with every variety of local climates.

A secondary meteorological center at Irkutsk is also very important for the supervision of stations and comparison of instruments. It is next to impossible to effect these objects from St. Petersburg.

It would be going too far to mention the efforts of the various government boards and societies to establish systems of meteorological observations in different parts of Russia, the more so as a unity of directions is now shown to be necessary to the progress of this science. Most of these systems are now united with that of the physical observatory, having adopted the same measures and methods. This is the case with the navy, which has meteorological stations on the White, Baltic, Black, and Caspian Seas, and also on the Pacific coast.

We shall now give a brief exposition of what is known of the climate of Russia, what are the advances made in latter years, and what remains to be done in this respect.

Our knowledge of the temperature of Russia is far more complete than that of the other meteorological elements. A striking fact has been brought to our knowledge in the last ten or fifteen years, that the mean temperature of winter is higher on the shores of the Arctic Ocean than to the south of it on the same meridian. Near the North Cape it is higher, even if we advance from southwest to northeast, while in the rest of Europe the northeast is the coldest quarter. This is due to the warm waters of the Gulf Stream, which flows along the north coast of Norway, and farther along the Russian Murman coast as far as the Svjatoi Noss, (Holy Cape.) The waters in this region never freeze, even masses of floating ice are never seen in them, and they communicate their temperature to the surrounding air. The places in the interior of the continent, far from the warming influences of the Gulf stream, will naturally have a lower winter temperature. No long meteorological observations have been made on the Murman coast, but the cities of Northern Norway situated on the same ocean, and subjected also to the influence of the Gulf stream, have a very similar climate. For the consideration of the winter and summer temperature of the same meridian from north to south we will refer to the following table:

Meridian about 22°.

	Winter.	Summer.	Diff.
Hammerfest, 71° N	23.9	49.0	25.9
Torneo, 66° N	6.4	57.9	51.5
Helsingfors, 60° N	20.7	59.0	38.3
Mitaw, 57° N	24.8	62.1	37.3
Warsaw, 52° N	27.0	63.5	36.5

Meridian about 29° *E. from Greenwich.*

	Winter.	Summer.	Diff.
Wardoe, 70° N	21.9	45.9	24.0
Petersburg, 60° N	17.4	60.8	43.4
Gorki, 54° N	18.1	61.5	43.4
Kiev, 50° N	22.6	65.3	42.7
Odessa, 47° N	27.9	70.3	42.4
Sevastopol, 45° N	36.9	72.7	35.8

We see that Wardoe has nearly the same temperature in winter as that of Kiev, situated 20° to the south on the same meridian. Even far from the shores of the Arctic Ocean the increase of temperature from north to south is very slow. It is accelerated only when we approach the shores of the Black Sea. Here again the warming influence of the salt-water basins is felt, while the temperature of summer also increases rapidly, and this for the reason that South Russia is principally a steppe, (prairie,) and such treeless regions are more heated by the sun than those covered with woods.

In the case of increase of temperature from north to south, Northern and Central Russia are very different from the United States, the former having the least and the latter the largest increase of temperature from north to south known in any extensive region. This increase is as follows in Russia, for 1 degree of latitude in degrees of Fahr.:

	Year.	Winter.	Summer.
From 64½° N. to 50° N	0.70	0.58	0.76
From 50° N. to 42° N	1.78	2.79	0.81
Difference	1.08	2.21	0.05

The temperature of the winter is also higher on the western coast of Nova Zembla than in the northeast of European Russia and Western Siberia. It has been found to be 5.7 on the 74° north in Nova Zembla, while it is — 6.5 at Berezov, (64° N.,) 1.6 at Ischim (56° N.,) and 10.2 at Kasalinsk, on the lower Syr-Daria, (46° N.,) so that it is only 4½°. higher, for a difference of 28° of latitude. The mildness of winter temperature on the Arctic Ocean is also illustrated by the fact that, while this ocean does not freeze so far as the Swjotoi Noss, the Caspian and Azov Seas, in a latitude of about 46°, freeze to a great extent.

The observations made in Russia furnish us with the means of tracing the changes of temperature from east to west, from the Atlantic to the Pacific Ocean. Generally the winter temperature decreases as we advance into the interior of the continent from west to east, and increases a little on the eastern shores of Asia. Yet, being much lower there than in Western Europe, the temperature in the interior is a little higher in summer than near the Atlantic, and decreases very rapidly near the Pacific, being much colder there than anywhere else on the same parallel in Europe or Asia.

Parallel of 70° *N.*

	Winter.	Summer.	Diff.
Wardoe, (Norway,) 29° E	21.9	45.9	24.0
S. E. coast of Nova Zemla, 57° E	3.2	35.6	32.4
Ustjavsk, 138° E	— 35.9	46.8	72.7

Parallel of 62° *to* 64° *N.*

	Winter.	Summer.	Diff.
Thorshavn, Ferõe Island 7° W	39.2	54.7	15.5
Soudmor, Norway, 6° E	27.1	55.8	28.7
Woro, (Finland,) 22° E	17.4	59.4	42.0
Ustsisolsk, 51° E	7.5	59.4	51.9
Berezov, 65° E	— 6.5	58.1	64.6
Jakutsk, 130° E	— 37.3	58.6	95.9

The difference between the limited climate of the shores of the Atlantic and the excessive climate of the interior of Eastern Siberia is strikingly illustrated by this example. The difference of the mean temperature of January and July in the last place is more than 100°, (January, — 41.4; July, 63.3.) Unfortunately we have no observations on the shores of the Pacific north of the 59th degree. The winter temperature would certainly be much higher there than at Jakutsk.

Parallel of 59° *N.*

	Winter.	Summer.	Diff.
Sandwick Orkney, 3° W	39.7	53.5	13.8
Reval, 25° E	22.3	59.0	36.7
Wologda, 40° E	12.9	60.8	47.9
Bogoslowsk, (1) 60° E	— 0.2	58.9	59.1
Ochotzt, (Pacific,) 143° E	— 8.1	52.1	60.2

Parallel of 56° *N.*

	Winter.	Summer.	Diff.
Glasgow, 4° W	38.8	57.2	18.4
Copenhagen, 13° E	31.3	62.1	30.8
Moscow, 37° E	14.7	64.3	49.6
Kasan, 49° E	11.0	64.8	53.8
Ischim, 69° E	1.5	63.6	61.1
Ajan, (Pacific,) 138° E	— 1.1	51.4	52.5

Parallel of 53° *N.*

	Winter.	Summer.	Diff.
Dublin, 6° W	41.6	58.6	17.0
Groningen, 7° E	35.1	63.5	28.4
Orel, 36° E	17.1	65.1	48.0
Pensa, 45° E	8.1	65.3	57.2
Barkaul, 34° E	1.0	64.9	63.9
Nicolajevsk, (Amoor,) 140° E	— 6.3	58.9	65.2
Petropavlovsk, Kamtchatka	20.3	55.5	35.2

Parallel of 46° *N.*

	Winter.	Summer.	Diff.
La Rochelle, 1° W	39.7	67.6	27.9
Venice, 12° E	38.8	72.5	33.7
Odessa, 30° E	27.9	70.3	42.4
Astrachan, 48° E	22.4	74.9	52.5
Kasalinsk, 64° E	10.2	73.6	63.4

(1) Above 700 feet eastern slope of the Ural.

Parallel of 39° *to* 40° *N.*

	Winter.	Summer.	Diff.
Lisbon, 9° W	50.0	70.0	20.0
Naples, 15° E	47.8	72.9	25.1
Lenkoran, (Caucasus,) 48° E	39.9	75.6	35.7
Pekin, (China)	28.8	77.9	49.1

The difference between the east and west is less sensible in the lower latitudes than north of the 50th degree. Scarcely will the winter be found colder anywhere on the 40th degree than in Pekin, and yet the difference between this place and Lisbon, on the Atlantic, is only 26°, while the winter climates of Dublin and Nicolajevsk differ by 47.9, and yet in the last place the temperature is already milder, because of the proximity of the Pacific. Blagovestschensk, on the upper Amoor, latitude 50°, has a winter temperature of —8.5, while in Helston, in Southwestern England, it is 46.0; difference, 54.5.

The summer temperatures are much more equable, being lowest on the Pacific shore, (Ochotsk, Ajan, Petropavlovsk.)

The ratio of the change of temperature in European Russia from west to east may be adopted as follows, in degrees F. for 1° of longitude: For the year: —0.25; winter, —0.56; summer, 0.13, (¹) that is, it increases very little in summer and decreases very rapidly in winter. In this last season the decrease from west to east and from south to north is the same.

The extensive plains of Russia and Western Siberia are very favorably situated for this kind of study, since the local peculiarities do not interfere with the result as much as in other countries. In Eastern Siberia the conditions are different; the country is intersected by many mountain chains; the vicinity of the Pacific modifies the climate to a great extent. On the other hand, as the points of observation are very widely scattered, it is not to be wondered that we know very little as yet of the climate of this interesting country. The pole of winter cold is situated, we know, at or near Jakutsk, on the Lena. As I have said before, the general system of meteorological observations did not extend so far northward, and it was a private individual, Mr. Neverof, to whom we are indebted for the twenty-five years' observations at Jakutsk. In Eastern Siberia, as in Western, the cold of winter is more intense in the interior of the continent than on the shores of the Arctic; the coldest known winter being at Jakutsk, latitude 62° N. In this respect Asia seems to differ very much from America, as here the coldest peninsulas and islands of the Arctic Ocean are far beyond 70° N.

The cause of this difference is probably that the Arctic north of the Asiatic continent is not entirely frozen, even in winter, while the nu-

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(¹) Hann, l. c., p. 394.

merous bays and sounds north of America are covered with an unbroken sheet of ice and snow. These bodies being very bad conductors of heat, their surface, and the air immediately overlying them, can cool to a great extent, as would a continent. These facts should be borne in mind when speaking of the climate of Eastern Asia and America, explaining the differences found, contrary to the general opinion of the similarity of the eastern shores of both great continents. The changes of temperature with elevation are also very much modified by the general features of Eastern Siberia, geographically and climatically. We know two high points of this country which have a higher mean winter temperature than the surrounding lowlands. These points are Mount Alibert 52° 30′ N. latitude, and 100° 41′ longitude E. of Greenwich, 7,300 feet high, and the mines of Wosnesensk, 58° 46′ latitude N., 115° 16′ E., 2,817 feet high.(¹) I give here the temperatures of January as they were observed, and the supposed temperatures of the same points at sea-level, according to Dove's isothermal map.

Temperature, of January.

	Observed.	Supposed.	Difference.
Mines of Wosnesensk..	+13.0	—26.5	13.5
Mount Alibert.........	2.1	— 6.0	8.1

We see that these high points have a much warmer winter temperature than was supposed. Wosnesensk is not very far from Jakutsk, where the temperature of January is —41° 4′, that is, more than 27° lower. Irkutsk is not far from Mount Alibert, and has a much lower winter temperature.

The increase with the height in winter in these two cases being shown, the question follows as to the cause. In clear, cold spring nights vegetables are often known to suffer from frost in low situations, while those on hills escape injury. This has long been explained by the action of radiation and gravity, when the air is calm. The colder and denser portions have a natural tendency to flow downward, and this tendency in a clear, calm night is not counteracted by the sun and winds, as it is generally during the day. Now a condition, analogous to that of spring, does prevail very generally in Eastern Siberia, especially in winter. The air is calm, the sky clear, the sun appears only for a short time, and the superposition of strata of air which would be caused by radiation and gravity is very little impeded. It is not to be wondered at, then, that a condition which is rare in Europe and the United States should be so common in Siberia, so as to raise even the mean temperature of high stations above that of low ones. A very general and strong

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(¹) For further particulars see "Zeitschrift der Österreichischen Gesellschaft für Meteorologie," year 1871, p. 52.

west wind was also noticed in winter at Mount Alibert, and described as a warm wind, while, as we have said before, calms with intense radiation prevailed in the lowlands.

These facts, as also much of what we begin to know about the plateaus of North America, show that the so-called laws of decrease of temperature with elevation are not generally applicable. The older notions on this point are taken from the observations in tropical South America and the mountain regions of Western Europe; that is, from maritime climates and mountain-chains. In regard to plateaus, these laws, we are sure, must be very different, but we are not able at present to state what they really are. In the present state of our knowledge we can only say that the decrease of temperature will be greater, first, in mountain-chains than on plateaus; secondly, in summer than in winter, or generally in warm temperatures than in cold; thirdly, in dry than in moist air.

The parts of Asia belonging to Russia present the most interesting problems relative to the influence of position on the distribution of temperature which can be found. Unfortunately these countries are scarcely emerged from darkness.

The range of temperature is an important element, which ought to be more studied than it is at present. I will refer only to an opinion very widely entertained in Russia, that the Siberian climate is very constant in comparison with that of Europe. This is erroneous, at least so far as Western Siberia is concerned, which has a very variable temperature especially in winter, scarcely less than that of the Mississippi Valley, so conspicuous in this respect.

The following table shows the mean highest and lowest temperatures of each month, observed with maximum and minimum thermometers, for twelve years, from 1851 to 1862.

Month.	St. Petersburg.			Lugan, (South-east Russia.)			Barnaul, (West Siberia.)			Nertschinsk, (2,000 feet,) (East Siberia.)		
	Maximum.	Minimum.	Difference.	Maximum.	Minimum.	Difference.	Maximum.	Minimum.	Difference.	Maximum.	Minimum.	Difference.
January	35.4	−11.2	46.4	39.7	−15.7	55.4	28.2	−43.1	71.3	2.1	−42.9	45.0
February	34.0	− 8.5	42.5	40.5	−13.4	53.9	37.1	−36.4	68.6	17.4	−35.1	52.5
March	39.7	− 2.6	42.3	56.3	− 2.4	58.7	41.2	−27.4	68.6	40.6	−22.2	62.8
April	55.2	15.6	39.6	77.0	21.0	56.0	63.7	1.4	62.3	60.8	2.1	58.7
May	74.3	29.1	45.2	86.9	34.5	52.4	82.0	23.0	59.0	79.2	21.4	57.8
June	79.2	39.2	40.0	92.7	42.6	50.1	87.1	36.7	50.4	87.6	34.7	52.9
July	83.3	48.9	34.4	95.0	50.0	45.0	89.4	46.3	43.1	86.5	45.1	41.4
August	77.4	45.3	32.1	93.9	44.4	49.5	85.5	39.6	45.9	84.4	35.1	49.3
September	68.7	34.9	33.8	85.3	34.7	50.6	75.6	25.9	49.7	72.3	22.8	49.5
October	57.4	23.0	34.4	74.8	19.2	55.6	62.6	4.8	57.8	57.0	− 1.1	58.1
November	43.5	4.1	39.4	56.1	5.7	50.4	41.9	−22.7	64.6	33.8	−25.1	58.9
December	37.0	− 4.7	41.7	43.0	− 2.2	45.2	33.1	−34.6	67.7	11.1	−38.6	49.7

Barnaul, in West Siberia, has the greatest range of temperature, at least from November to May. In the winter Nertschinsk has a relatively small range; it is the constant winter of Eastern Siberia; in January the range is even smaller than at St. Petersburg. The maxima are clearly seen in Nertschinsk in March and November, while January and July have the least range. The temperature sometimes may fall as low in Western Siberia as in the eastern part of that country, only in the latter the cold is constant, and the thermometer never rises above the freezing-point from the first days of November to the middle of March. The following table gives the absolute maxima and minima of the winter months in the same period; to which I have added those of Jakutsk for ten years, 1845–1854, from observations taken thrice a day

Month.	St. Petersburg, absolute.			Lugan, absolute.			Barnaul, absolute.			Nertschinsk, absolute.			Jakutsk, absolute.		
	Maximum.	Minimum.	Difference.	Maximum.	Minimum.	Difference.	Maximum.	Minimum.	Difference.	Maximum.	Minimum.	Difference.	Maximum.	Minimum.	Difference.
Dec ..	41.0	−17.5	58.5	52.7	−33.2	85.9	40.5	−67.0	107.5	27.0	−44.3	71.8	0.5	−64.0	64.5
Jan ..	38.3	−31.0	69.3	45.3	−31.0	76.3	36.5	−64.7	101.2	14.0	−49.7	63.7	0.	−63.6	63.6
Feb ..	37.2	−23.1	60.3	56.3	−25.1	81.4	42.1	−58.7	100.8	28.6	−45.6	74.2	11.7	−60.1	71.8

The absolute range is less in January in Eastern Siberia than in any other of the given points, while it surpasses 100° at Barnaul. At this last point 36°.5 were observed on the 4th of December, 1860, and —67.0 on the 16th of the same month, being a difference of 103.5° in twelve days. These enormous variations of temperature have also been observed in the valley of the Jenissei—for example at Krasnojarsk, 33.1 on 28th of November, 1840, and —51.2 on the 30th, being 84.3 difference in 46 hours. In Eastern Siberia these enormous changes are unknown in mid-winter.

The pressure of the air has received much less attention in Russia than the temperature, and this can be said of the observations, as well as of their calculation and tabulation. We do not possess as yet good barometrical tables, although we may hope to have them, as *Lieutenant Rikatschef and Baron Maydell*, both of the physical observatory, are occupied with the reduction and discussion of all the barometrical observations which they could obtain in Russia. The largest collection of barometrical means for Russia is that in Buchan's work on "Mean pressure and winds."

The great summer depression of the barometer is strongly marked in Southern and Central Russia, and is perceptible even farther to the west. It probably attains its greatest amount on the plateau of Central Asia, from Eastern Turkestan to the Gobi, but we have not a single year of continued barometrical observation in this widely-extended country. The greatest amount of the summer depression known to us was observed west of the plateaus, on the upper Irtysch and east of them at Pekin. The following table shows the distribution of pressure in different months:

	January.	July.	Difference.
Western Europe.			
Reikiavig, (Iceland)	29.47	29.69	.22
Greenwich	.76	.81	.05
Hammerpest, Norway	.51	.73	.22
Udine, North Italy	.63	.58	—.05
Vienna	.38	.30	—.08
North and West Russia.			
Archangel	.74	.70	—.04
St. Petersburg	.85	.78	—.07
Kostroma	.34	.15	—.19
Warsaw	.59	.44	—.15
Kiev	.88	.67	—.21
Eastern Asia.			
Irkutsk	28.78	28.19	—.59
Nertichinsk	27.96	27.56	—.40
Pekin	30.24	29.67	—.77
South and East Russia.			
Odessa	29.88	29.67	—.21
Lugan	.83	.48	—.35
Samara	.80	.43	—.37
Orenburg	.87	.44	—.43
Astracan	30.22	29.88	—.34
Caucasus.			
Redut Kale	.09	.84	—.25
Tiflis	28.55	28.29	—.26
Baku	30.21	29.81	—.40
West Siberia and Central Asia.			
Bogoslovsk	29.28	29.05	—.23
Catherinburg	29.13	28.78	—.35
Barnaul	.81	29.10	—.71
Novo Petrovsk	30.08	.72	—.36

The monthly differences of pressure have only lately attracted general attention. The cause of this is that in Western Europe, Eastern North America, and the tropics, these differences are very small. It was only after the observations in Siberia, China, and India were known, that the barometrical depression of the summer was noticed, and the summer monsoon of India and China was explained by the rarefaction of the air in the middle of the continent, and the consequent drawing in of the air of the surrounding seas.

Now that the relations of the pressure to the winds are better known, much more attention is given to barometrical observations, and especially those of the Asiatic continent attract the attention of all meteorologists. There are two problems which remain to be solved here in regard to this matter: (1) Barometrical observations in the interior of Asia, to ascertain the true amount of summer depression at a distance from the influence of the ocean, and (2) a line of levels from the Baltic to the Pacific Ocean. So long as the true height of Siberian points of observation is not known, and the adopted heights may be wrong from 300 to 500 feet, we can know very little of the pressure of the air in this region. It is a *circulus vitiosus*, as the heights are measured by the barometer, and afterwards the observed barometrical readings are reduced to sea-level, on the supposition that the obtained height is true. The isobars drawn in Buchan's excellent work on the mean pressure are not free from this reproach, as any isobars must be so long as the actual height is not accurately known. The plan of a line of levels from the

Ural Mountains to Lake Baikal was discussed last year by a special commission of the Russian geographical society, and the importance of this work clearly pointed out. The council of the society, however, declined to undertake the work immediately for want of adequate means, yet it was hoped that private individuals would help the society in this important enterprise, the more so as it has a practical bearing. A line of railroad from Nijny-Novgorod over the Ural to Irkutsk, and from thence to the Amoor River, or directly to China, is in serious contemplation. Its feasibility is beyond doubt, as the difficulties are far from being so great as those of the American Pacific Railroads.

The barometrical minima have an important bearing on the production of storms, as it is now well ascertained that these violent commotions of the atmosphere are caused by a great barometrical difference between places near each other. Generally the barometer is very low in the center of a storm, this center drawing in from every direction the surrounding air. On the other hand, a great barometrical depression can only be sustained by the condensation of vapor; cold and dry continental areas will then arrest the progress of storms moving towards them. The coldest region of Siberia can have no storms in winter, if the foregoing views are correct. This is also the case; for example, at Nertschinsk, we find scarcely a moderate wind in the three winter months, calm or very light northwest winds being the rule. In Western Siberia calms prevail in very cold winter months, while the winds are stronger in warm winters. In considering European winter storms, *Mohn arrives at the following conclusions:

Storm-centers move from S. 71° W. in the Arctic and Atlantic Oceans, from N. 7° W. in Scandinavia and Germany, and from N. 27° W. in Russia. He says that the air is too cold and dry in Northern and Eastern Russia to sustain the barometrical depression; the condensation on the southern side is much greater, and so the storm moves southward, while the barometer rises in its center. The mean pressure in the center of storms is 28.68 inches over Scandinavia and Germany, and 29.13 over Russia.

Mohn has not attempted to trace the European storms to Siberia, as the observations were too few for this purpose. I have tried to gain some knowledge of the subject of storms by considering the barometrical range; that is, the mean maxima and minima of each month.† I can, however, only briefly state the results: The mean barometrical minima of the winter months, reduced to sea-level, are: At Reikiavik, in Iceland, 726 millimeters, or 28.5 inches; at Hammerfest, Norway, 730 millimeters, or 28.7 inches; at St. Petersburg, 737.3 millimeters, 29.0 inches. At Barnaul, (West Siberia,) 754.7 millimeters, or 29.7 inches; at Nertschinsk, (East Siberia,) 763 millimeters, or 30.04 inches. In the last-mentioned place, the mean barometrical minima are an inch and

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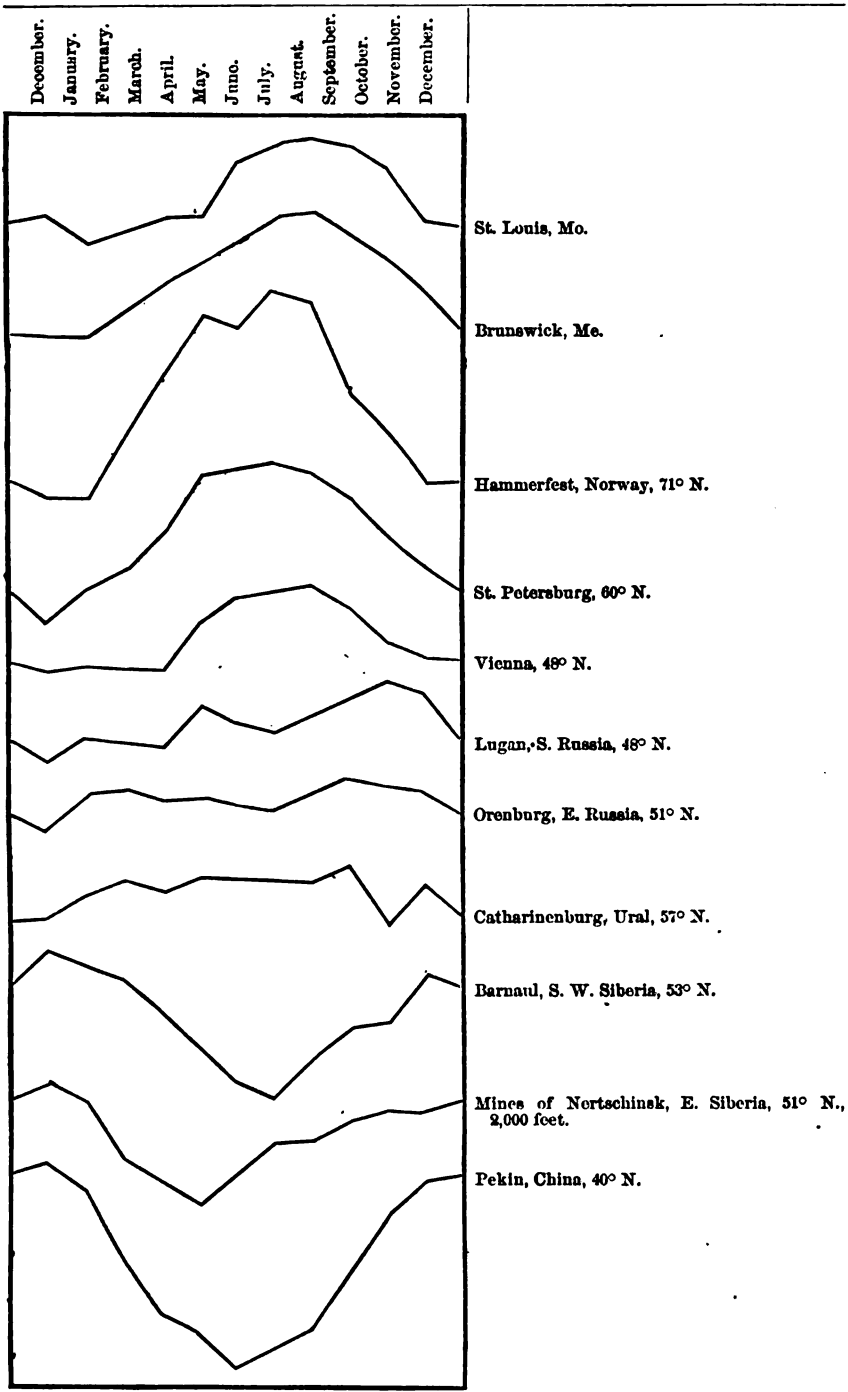
* In his "Storm-Atlas."

† Zeitschrift der österreichischen Gesellschaft für Meteorologie, year 1871, p. 161.

Mean monthly barometric curves.



a half higher than in Iceland. In Siberia the mean minima are also higher in January than in the other months, while generally in Europe and North America the contrary is the case, indicating a greater intensity of the storms in midwinter. In the annexed diagram the movement of the minima is graphically represented. North America and Western Europe have the same system of curves, the minima being highest in summer, lowest in winter. In Siberia and Eastern Asia the contrary is the case; this is especially marked at Pekin. The stations of Lugan, in S. Russia, and Catharinenburg, on the Ural, occupy an intermediary position, having neither the oceanic nor the true continental type. The greatest difference between the last two places being that in Lugan October has the highest minima in the year, and Catharinenburg the lowest. This is not accidental. In October the conditions of the temperature and moisture of the air on the Ural, and in Siberia, are more favorable to the propagation of storms than in winter. In the same season the Atlantic storms take a more northern course, causing a great depression of the minima on the Ural. In Southern Russia the pressure is generally high in autumn, as also the minima. October is not a stormy month there, while November and December are.

It is possible that in October Atlantic storms may reach as far as Jakutsk. The sky is generally overcast there, it is the most cloudy month of the year, and the number of west and southwest winds is great. The temperature has not yet fallen so low, even in the northern interior of Siberia, as to prevent the propagation of storms.

We shall next consider the winds, which are in so intimate a connection with the pressure of the air. I have said before that Wesselovsky had proved the existence of a belt of eastern winds during autumn and winter in Southern Russia, while at the same time the southwest winds prevail in the northern part of the country. The movements of the atmosphere are better known at the present time as far as the Jenissei, and I have been able to prove the existence of a belt of prevailing southwest winds in Northern Siberia, and of eastern winds in the south of that country and Central Asia. The division line runs about the parallel of 50° or 52° north in Siberia, and a little more south near the shores of the Black Sea.*

This is illustrated by the following table, which shows the percentage of winds in winter in Western Siberia, Central Asia, and Southeastern Russia:

South of 52°.

	N.	N. E.	E.	S. E.	S.	S.W.	W.	N.W.
Orenburg	11	17	19	8	11	17	9	7
Semipalatinsk	1	4	26	19	15	13	13	9
Raimsk, (Syo-Daria)	9	19	21	18	8	7	12	8
Astrachan	6	16	22	16	3	8	15	15

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*"Tswästia" of the Russian Geographical Society, year 1871, No. 5.)

North of 52°.

	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.
Eastern Ural, (three stations)	5	5	1	10	10	24	27	17
Tobolsk	4	4	7	30	21	12	9	13
Jschim	8	5	6	8	12	41	9	10
Kourgan	12	8	9	10	20	15	16	9
Omsk	4	13	6	9	10	24	16	19
Barnaul	8	13	1	5	15	44	9	5
Krasnojarsk	4	6	2	2	2	66	14	5

The prevalence of southwest winds in the northern part of the country is clearly seen in this table. Even Orenburg and Semipalatinsk, situated between 50° and 52°, have prevailing east winds, but a great number of southerly also, while Astrachan and Raimsk have much less southwest and much more northeast winds than all the other points. The differences we notice between the several points are easily accounted for, if we consider the rough mode of observing the wind-gauge and the different local circumstances having an influence on the indications of this instrument.

I have also noticed an influence of the upper river valley, the winds in the direction of this being generally more frequent. For example, at Tobolsk the Irtysch comes from the southeast, and the winds from that quarter prevail. At Jschim, Barnaul, and Krasnojarsk the rivers flow from the southwest, and so the local direction corresponds with the general one, giving an enormous prevalence to the southwest winds. At Omsk only this is not the case; the rivers flow from east and southeast, and yet the prevailing wind is southwest. This is probably due to the very level position of the surroundings of Omsk. The winds of this place can be considered as typical for Western Siberia, north of 52°, that is, a moderate prevalence of the southwest, extending also to the south and west winds. Three or four years ago nothing accurate was known as to the winds in the basin of the Yenissei. Now we know that the southwest extends as far as there, and probably even to the east of this river.

Further to the east the winds are so rare and irregular in the winter, and calms so general, that I may call this region one of prevailing calms. It embraces the basin of the Lena and the tributaries of the Northern Ocean, east and west of it, as also Transbaikalia. It is the region of the Siberian meteorological pole. The atmosphere is generally clear and calm, with cold generated on the spot by radiation, and not brought from other places by the winds. We must not imagine that this region is of equal magnitude every winter; it extends and contracts unperiodically. In very cold winters it stretches westward to the Ural, and even farther, while the warm winters of Western Siberia are those in which it shares in the atmospherical currents of Europe. To prove this I calculated the temperature of the winds at Krasnojarsk in the winter months of 1870–'71, as given in the following table, in which N. C. indicates the number of winds observed:

Month.	N. E.		E.		S. E.		S. E.		S. W.		W.		N. W.		Calms.	
	N. C.	Temperature.	N. C.	Temperature.	N. C.	Temperature.	N. C.	Temperature.	N. C.	Temperature.	N. C.	Temperature.	N. C.	Temperature.	N. C.	Temperature.
December..	0	......	0	......	1	−35.5	0	......	44	0	5	−24.7	6	−4.0	37	−27.6
January ...	9	−12.3	4	−11.0	0	......	0	......	55	0.7	9	−6.7	0	......	16	−13.2
February ..	5	−1.5	1	24.6	2	21.2	6	9.0	46	1.4	9	5.2	2	−19.1	13	9.5

The temperatures of the months were: in December, —12.2; January, —4.2; February, 4.0. February is much warmer than December, yet the temperature of the prevailing southwest winds is nearly the same, differing only 1.4, while the mean temperature differs by 16°.2. But we see that in December calms were much more prevalent than in February, and the temperatnre of the calm days very low. To show more clearly that the movement of the air in this region tends to elevate the temperature, I have calculated separately the temperature of light, moderate, and strong southwest winds.

Month.	S.W.		
	Light.	Moderate.	Strong.
December	—3.1	—2.4	9.7
January	—2.0	1.2	13.8
February	2.1	—2.4	14.4

The strong winds are by far the warmest, the difference of temperature between light and strong being 12.8 in December, 15.8 in January, and 12.3 in February. The region of calms, or of the Siberian pole, is bounded on the south and east by that of the Asiatic monsoons, or periodic winds, blowing from the land in winter and from the sea in summer. It is only within the last year that the true extent of this interesting region has become known. In the winter the interior of the continent is cooled by radiation, the atmospheric pressure rises, and the air flows out to the Indian and Pacific Oceans, where the pressure is less. In summer the continent is heated, the pressure is much lowered, and the air from the surrounding seas flows in upon Asia. Encountering high mountains on the south and east, the sea-air is forced up into a higher and colder altitude, and loses its vapor in copious rains; so the gap can never be filled, as the precipitation causes a low pressure near the mountain sides. These movements of air are especially marked in Southern and Eastern Asia, because the heated plateaus of the interior are there nearest to the ocean. Air is also drawn into Central Asia from the Arctic and Atlantic Oceans, but, having a much longer distance to travel before reaching the mountains, and being originally colder, it does not cause such a great precipitation. The in-draught from the north and west is also less regular, since the pressure over the Arctic is not high in summer, and the air of the Atlantic is also drawn toward the deserts of Africa where the pressure is low in summer.

The Asiatic monsoons were first known to the Europeans in India, and therefore we often find them called Indian monsoons. It is also supposed that they always blow from the northeast in winter, (dry monsoons,) and from the southwest in summer, (wet monsoons.) In the lately published "pilot-chart" of the British admiralty the monsoon region is represented as extending northward to Southern China only. But the winds much farther to the north have the same periodical character. Even in Northern China, Japan, Mantschuria, the Russian Amoor provinces, and on the western coast of the Sea of Ochotsk, cold, dry winds (northwest) from the interior of the continent generally prevail in winter, while in summer they are from the sea, bringing cloud and rain. There is, therefore, no reason why we should not extend the Asiatic monsoons to these countries, since their climates are of the same character as that of India, the temperature alone excepted, the winter being the clear, dry time of the year, and the summer being the rainy period. Sometimes the summer monsoon extends as far inland as Lake Baikal. In 1869 this lake, the greatest fresh-water basin of the world except Lake Superior, rose more than 10 feet above its ordinary level, causing disastrous floods in the neighborhood. Such copious and long-continued rains in summer are unknown in European Russia; the great rivers are unaccompanied with freshets in summer, especially those traversing great lakes, as the Neva.

The following table shows the periodical character of the winds in the regions of Eastern Asia:

Percentage of winds at Nicolajevsk, mouth of the Amoor.

Months.	N.	NE.	E.	SE.	S.	SW.	W.	NW
January	10	2	1	0	0	4	57	26
February	10	4	3	1	0	3	42	36
March	16	11	13	4	1	3	30	23
April	6	14	31	9	1	3	23	13
May	5	14	35	14	1	1	20	9
June	3	18	42	20	1	1	8	6
July	6	9	46	14	1	1	15	9
August	6	10	36	9	1	2	13	23
September	10	13	19	9	0	2	21	36
October	9	12	12	4	1	3	31	29
November	7	5	4	3	0	3	37	40
December	10	6	4	1	1	5	50	22

The western winter monsoon is established as early as the end of September; that is, in the time of the typhoons of the Southern China seas. The navigators in the Sea of Ochotsk have long known the periodicity of the winds in this region, of which they take advantage in going in the summer from Kamtschatka to the western coast of this sea, and returning in September or October, when the western winds have fairly set in.

The extremely unpleasant cold and damp summer climate of these regions is caused by the prevailing east wind coming from the cold Sea of Ochotsk, a true polar basin transfered to a lower latitude. The yearly increase of temperature is also checked to a great degree by this influence, the warmest month being generally August, when the sea-water has acquired a higher temperature.

The summer rains are very copious, even in places inland as far as Pekin. In this place, as also at the mines of Nertschinsk, the fall of water is more than fifty times larger in July than in January. In the last place there is hardly any sledging in winter, though the temperature remains six months below the freezing-point. The countries on the Lower Amoor and Japan have more of snow and rain in autumn and winter. The east winds from the adjoining sea are seldom experienced, yet when they do occur the precipitation is copious, the difference of temperature between land and sea being very great. We find a resemblance to this in the climate of Eastern North America, where the rainfall is more copious than in Europe; yet the sky is clearer and the number of rainy days less.

Precipitation in inches.

	Year.	Winter.	Spring.	Summer.	Autumn.	Greatest.	Least.
Pekin	24.21	0.64	2.23	17.36	4.00	8.06 July.	0.14 Jan.
Nertschinsk	15.47	0.30	1.73	10.64	2.80	3.96 Aug.	0.07 Feb.
Hakodadi, Japan	44.01	8.14	8.49	16.46	10.94	8.21 July.	1.89 Jan.

I have said before that the monsoon climate is characterized by a generally clear winter and a rather cloudy summer. The amount of cloudiness has only begun within the last few years to attract the attention of scientific men. An extensive collection of tables of this element has been commenced by Kamtz, and continued by Wild, who has published the results in the new "Repertorium für Meteorology." They embrace many places in Russia and in Siberia. I present here an extract from these tables, in which the means of several places have been combined together. The amount of cloudiness is expressed in percentage; a cloudless sky taken as zero.

	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	Year.
(1) **Alaska:**													
Sitka	63	65	66	61	63	66	72	75	74	71	73	68	68
(2) **Eastern Asia:**													
Pekin	23	25	31	39	46	49	56	63	56	46	30	32	42
Ochotsk, Ajan, Nicolajevsk	26	25	27	35	37	48	47	48	50	44	35	34	37
Mines of Nertschinsk	19	13	14	22	36	44	47	48	46	44	38	25	33
(3) **Central and West Siberia:**													
Jakutsk	46	46	35	26	37	49	49	47	49	55	69	48	46
Barnaul	51	41	39	35	38	37	39	38	38	55	46	54	41
Tobolsk, Tara, Tschim	54	46	43	41	42	44	45	44	47	40	58	58	48
Bogoslowsk and Berezov	42	43	40	38	43	46	44	43	46	53	52	50	45
(4) **Central and Northern Russia:**													
Weliki-Ustjug, Glazov, Slobodskoi	66	60	61	52	47	42	40	34	43	49	67	71	52
Ardatov, Balachna, Gorbatov, Tambov, Simbirsk, Wolsk	66	60	60	50	49	44	42	42	41	47	62	68	52
Anandus, Reval, Baltischport, Riga	59	54	52	48	44	38	37	34	35	44	56	61	47
Yoski, Kaluga	75	76	65	59	49	43	42	41	42	50	64	74	55
(5) **Southern Russia:**													
Kursk, Orel	70	63	58	50	47	40	38	38	37	47	55	65	51
Sudscha, Lugan, Catherinbosburg	72	63	64	57	42	33	31	31	30	38	52	68	48
Odessa, Nicolojev	73	70	68	62	52	44	40	36	32	36	49	68	52
(6) **Southeastern Steppes:**													
Astrachan, Ft. Alexander, Uralsk	57	57	49	43	34	28	26	24	21	24	34	39	37
Raimsk, Kasalinsk, and Fort Perovski	46	41	40	37	27	28	25	23	19	20	24	34	30
(7) **Caspian:**													
Baku, Lenkorañ, Ashur-Ade	59	59	64	62	56	48	44	38	39	46	49	59	51

The contrasting climates are those of European Russia and Eastern Asia, the first having the greatest amount of cloud generally in December, the last in July or August. The greatest part of Siberia is a land of transition, having the least amount of cloud in March and the greatest in October or November. Barnaul has very little cloudiness from February to August, so as to form a transition between the steppes on the southwest, and the countries on the east of it. Yet it must be said that the accuracy of this table is not very great, the amount of cloudiness not being observed in former times in Russia, and only such designations as clear, cloudy, overcast, &c., being given, and sometimes also the different qualities of clouds, (*cirro cumulus*,) &c. It seems especially that the amount of cloudiness in Southern Russia is less than that shown in Wild's table, and the same probably applies to the southeast steppes. In regions where the sky is clear for some weeks together the observers will record "cloudy" if only a few clouds appear, &c. A cloudiness of from 70 to 72 at Odessa and Lugan seems to me quite impossible.

I have already spoken of the summer winds in the monsoon region. In the region of the southwest winds the change from winter to summer is far less marked, the winds being a little more from the north in summer, the prevailing direction being still west. In the steppes of Southern Russia, and far into Central Asia, the winds are also west in June and July, the prevailing direction being the opposite of that of winter. Yet this has not so great an influence on all the features of the climate as in Eastern Asia—1st, because winds from other directions are more or less common in both seasons; and 2d, because there is not the contrast existing in Eastern Asia between the winds from the continent and those from the ocean.

In Transcaucasia the winds are also generally easterly in winter and westerly in summer, as on the northern shores of the Black Sea. Yet the influence of the mountains and sea is strongly felt. On the Caspian, especially, the day and night breezes are very regular in summer. The Persian sailors know this very well, and in going from the south to Astrachan they keep along the eastern shore, where the breezes are stronger than on the western.

We possess very few observations on the quantity of falling water, and this has induced the Geographical Society to establish a more general system, especially for this element. Yet we must wait at least from ten to fifteen years before having reliable data from the new stations. Some general features can, however, be ascertained even now, with the aid of the few points of observation we possess. In a work on the rains of Russia* I have divided the country thus:

1. Region of prevailing summer rains, with a maximum in July: Including the northern part of Russia and Siberia as far as the 50° in the west, and 54° in the east.

2. Region of prevailing summer rains, with a maximum in June: Including the country south of the former, being the principal part of the steppes (prairies) of southern and eastern Russia.

The two regions differ, moreover, in this, that the second has a very marked dry time in September and October, with easterly winds, and a second maximum in November.

Possibly the difference of the time of most copious rains coincides with the physical aspect of the country, being well wooded in the north and nearly naked in the south. In the beginning of the summer the grasses and corn-fields of the steppes are green, and in this condition the evaporation is considerable, giving enough of vapor to the air, while at the same time the cold caused by evaporation is favorable to the condensation of moisture. In July the grasses are already withered, the corn ripened, and in these conditions the plants evaporate much less water, and therefore the rains are less frequent and copious.

In the wooded region of the north evaporation from the leaves of trees goes on the whole summer, the best conditions for rain being in July, the hottest month. In the United States the conditions are similar. The country east of the Rocky Mountains is also principally one of summer rains, but in the prairie States the maximum of falling water is reached earlier; so in Missouri and Kansas there is a marked maximum in June; farther to the south even in April and May, which is due to the earlier vegetation. In the wooded Atlantic sea-board, on the contrary, there is no such tendency to an early maximum, the rains being very equally distributed in the Northern States, and having a maximum in July or August in the South.

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* To be published in the "Sapiski" of the Russian Geographical Society; also, "Zeitschrift der österreichischen Gesellschaft für Meteorologie," year 1871, p. 193.

Besides the above stated difference between the north and south, there is a marked one between the east and west of Russia. Precipitation in winter is much less in the former. This is not due to the difference of the currents of the air, but to the winter cold, which is greater in the east. The warm, moist southwest winds contain little vapor in Eastern Russia, and therefore the quantity precipitated cannot be great. Yet snow falls occasionally, and in small quantities, even at Jakutsk, which has the coldest winter of which we have any knowledge. Snowfalls have been observed there at temperatures of from − 40 to − 46 Fahr. The rain-fall of summer does not diminish generally from the Baltic to the Obi in Siberia. Local circumstances seem to have a great influence on the summer rains, but their study requires many more observations. There are also two small regions with prevailing rains in autumn—one on the Baltic coast, comprising Southwest Finland and Libau; another in the southern part of the Crimea, south of the Jaila Mountains.

3. Nearly rainless region of the Caspian and Kirghez steppes. Here the amount of rain falling yearly is from 4 to 6 inches, and is very irregularly distributed. It is an arid, desolate country, in which agriculture is impossible without irrigation. The boundary of the region of summer rains No. 2 is very clearly marked on the west. It is the high, right bank of the Volga from 50° to 48° N., and a line of heights called Jergeni, forming its continuation to the south, extending to the Kuma-Manytsch depression, about 46° N. On the south of this depression the plateau of the Western Caucasus rises, and its eastern border is also the line of division between the two regions, the eastern being low, salt, and desert; the western having regular summer rains, and a luxurious natural grass vegetation. A great part of it is already under cultivation, yielding excellent corn-crops.

The mountains of Central Asia have more rains than the steppes at their foot, and the rivers descending from them are extensively used for irrigation. The inhabitants are well aware of the benefit of this system, and, though not very civilized, have excellent modes of irrigation. The whole of Central Asia, as much as we know of it, has a similar climate, the sedentary inhabitants gathering around mountain streams, and often draining them to the last drop for their fields.

4. East of this country is the monsoon region of Eastern Asia, with an enormous prevalence of summer rains. The principal features and extent of this region have been already described. These are the four principal regions from the Baltic to the Pacific. The floods of the riv-

ers furnish us also means of distinguishing the European climate from that of the Pacific slope. All great rivers of European Russia, as also the Obi and Jenissei, have one principal flood in the year, after the melting of the winter snow. The rise of water is more or less protracted, owing to the climate and extent of the basin, so that the highest stage of water is reached as late as the 15th of June by the Volga at Astrachan, owing to the late melting of the snow on the western slopes of the Ural and the enormous distance the water has to pass from thence to Astrachan.

The summer rains are not long enough continued, and too local to have great influence on the rivers.

The Angara River, tributary of the Jenissei, does not rise generally in spring, the quantity of snow falling there being too small. But sometimes the river and Lake Baikal, which it traverses, rise very high in summer. The Amoor has also no great flood, due to the melting of snow, but rises very high sometimes in summer. The disastrous flood of 1872 will long be remembered by the inhabitants of the country. The rivers of China have also floods, due to the spring and summer rains, and, like all rivers in such condition, their floods are very disastrous and irregular.

The Caucasian provinces, though of small extent, show great differences in the quantity and character of their rains. South of the principal chain we must distinguish three principal belts: (1) that of the eastern coast of the Black Sea, a country of very copious precipitation. It includes Mingrelia, Imeretia, Guria, and Abchasia, being bounded on the northeast by the principal chain of the Caucasus, and on the east by the Suram Mountains, separating Imeretia from Grusia. About 60 inches fall in the year, which is tolerably well distributed, the maxima being in June and December. A warm climate and copious rains produce a rank, luxurious vegetation, having some features of that of the tropics. Climbing plants are especially favored by the climate, and the trees of Central Europe attain immense dimensions. (2.) Grusia has a less rainy climate, the maximum falling in May. Irrigation is found much necessary in the valleys, while the mountain-sides, from 2,000 to 5,000 feet high, are clad with forests. The maximum of rain-fall in May is strongly marked, this month at Tiflis having also the greatest number of rainy days and the greatest amount of cloud. On the higher plateau of Armenia, 4,800 feet, May is also the rainiest month, as it is due north of the Caucasian chain at Alagir. (3.) The western shores of the Caspian have sub-tropical rains—that is, the greatest quantity falls in autumn and winter, while the summer is decidedly dry. The distribution is nearly the same along all this shore, while the quantity varies much; Lenkoran, for example, has more than 50 inches, while Baku has only 10. The vapor coming from the Caspian, places having mountains to the westward receive copious rains. Lenkoran has a similar position, the Talysh Mountains rising from 5,000 to 7,000 feet due west of the town. Baku is situated in a low, arid country north of this place. The vicinity of Kuba and Derbent has much more rains, because the ramifications of the high Shah-Dagh approach the Caspian. This country has magnificent forests and very favorable conditions for agriculture.

I have already said that the opening and freezing of rivers was long ago observed in Russia. These data give us the means of ascertaining something of climates where no thermometrical observations have been made.

In the following table the rivers are arranged according to natural basins. The principal rivers are taken from their source to their mouth, and their affluents afterwards.

Number of days the rivers were frozen.

BASIN OF THE PACIFIC.

Amoor at Nicolajevsk	193
Onon near Nertchinsk	170

BASIN OF THE ARCTIC.

Yana at Ustyansk, 70° N	260
Lena at Kirensk, 57°	204
Lena at Yakoutsk, 62°	204
Yenisei at Yenisseisk, 58°	171
Angara at Irkoutsk, 52°	87
Obi at Barnaul, 53°	167
Irtish at Tobolsk, 58°	173
Tom at Tomsk, 56°	180
Tobol at Kurgan	171
Sosva at Beresov, 64°	207
Isset at Catherineburg	179
Petchora at its mouth, about	240
Dwina at Archangel, 65°	191
Suchona at Ustjug	168
Wytschegda at Jarensk	132
Wologda at Wologda, 59°	170
Onega, 64°	169
Tana at Utsjoki, 69°	197

BASIN OF THE BALTIC.

Kemi near Toneo, 66°	207
Enontekois, 68°	228
Uleo at Uleaborg, 65°	201
Neva at St. Petersburg, 60°	147
Narova at Narva, 59°	137
Embach at Dorpat, 58°	131
Dwīna at Witebsk, 56°	134
Dwīna at Riga, 57°	126
Niemen at Kovno, 54°	90
Vistula at Warsaw, 52°	85

BASIN OF THE BLACK AND AZOV SEAS.

Danube at Galatz, 45°	48
Dneper at Kiev, 50°	97

Dneper at Catherinenslav, 48°	91
Dneper at Kherson, 46°	80
Sosch at Gomel, 52°	122
Berezina at Borissov, 54°	129
Pripet at Turov, 52°	105
Don at Ust-Medvedizo, 49°	135
Don at Aksai, 47°	107
Woroneje at Woroneje, 52°	135
Lopan at Charkov, 50°	127

BASIN OF THE CASPIAN.

Wolga at Tver, 56°	147
Wolga at Yaroslav, 58°	152
Wolga at Kostroma, 58°	161
Wolga at Kasan, 56°	153
Wolga at Samara, 53°	150
Wolga at Saratov, 51°	132
Wolga at Astrakhan, 46°	99
Oka at Orel, 53°	130
Jna at Tambov, 53°	146
Kama near Dedjuchin	180
Kama at Ussolje, 60°	176
Kama at Perm, 58°	160
Kama at Jelabuga, 56°	160
Vjätka at Vjätka, 58°	163
Bjelaja at Ufa, 55°	158
Ural at Orenburg, 51°	164

BASIN OF THE ARAL SEA.

Syr-Daria at Khodjent, 40°	0
Syr-Daria at Jt. Porovski, 45°	98
Syr-Daria at Kasalinsk, 46°	123

The time of opening and closing of rivers depends not only on the intensity and duration of frost, but also on many local conditions, as, for example, the strength of the current. On this account the Angara at Irkutsk is frozen only half the time it would be if its current were not so very strong. This river very seldom freezes near Lake Baikal, and at Irkutsk the freezing begins at the bottom. Rivers of such an exceptional character are seldom met with in Russia, as the greatest part of the country is a level plain, only slightly undulating. There seems not to be a very great difference in the time at which large and small rivers are frozen; the former freeze and open a little later. Great and deep bodies of water are not so easily cooled as small, and so great rivers freeze later. The later opening in spring has a different cause: The ice of the smaller rivers is broken by the inrush of water from melted snow. The channels of great rivers do not fill so rapidly and their ice must be more worn before it breaks. The Volga at Saratov, where it carries an enormous body of water, and the Oka at Orel, where it is a very small river, are covered with ice nearly the same number of days. But the Volga is frozen only from the 8th of December to the 19th April, while the Oka freezes the 25th of November and opens the 4th of April. It is thus closed thirteen days earlier and opened fifteen days earlier than the Volga.

The rivers are frozen a much longer time in Eastern than in Western Russia; for example, at Orenburg the river is one hundred and sixty-four days covered with ice; at Turov, in the same latitude, the river is one hundred and seven days frozen, and at Warsaw only eighty-five days. The duration of cold weather is the principal feature of the climate to be considered. Furthermore, extremes of cold seem to have very little influence; for example, in the winter of 1870–'71, the coldest of this century, the Neva froze seven days later and opened ten days earlier than is generally the case. In this winter the cold was restricted to the months of December, January, and February, the months of November, 1870, and especially March, 1871, being comparatively warm.

An extensive collection of data relating to the freezing of rivers, lakes, and bays is in progress in Russia. It is the work of Lieutenant Rikatschef, who presented his plan to the Geographical Society in the beginning of 1870. Circulars asking for such observations were sent to every part of the empire, and it was also thought necessary to extend the work to foreign countries. I am happy to say that this plan received the hearty assistance of the late Professor Coffin, and of Professor Henry, who tried to obtain all available data from North America.

I have now briefly stated the most important facts relating to the meteorology and climatology of Russia, and will end with expressing the hope that the practical application of science to weather-forecasts may soon extend to my country, and that thus telegraphical weather-communications may encircle the globe. Everything that is useful to mankind spreads so rapidly in our day that we shall probably see at no distant date, difficult as it may seem, the system extend even to countries nearly desert, such as Eastern Siberia and Alaska. We shall then see our Baltic harbors warned of the approach of Atlantic storms many days before their occurrence, while the Russian stations on the Pacific will at the same time render a similar service to California and Oregon.

I mention here some of the principal sources of information relative to the meteorology and climatology of Russia, especially those published in German or French, which are more generally known than the Russian language.

Annuaire magnétique et météorologique, from 1837 to 1848.

Annales de l'observatoire physique central, from 1849 to 1864, containing the detailed, partly horary, magnetical and meteorological observations of the great stations.

Correspondance météorologique, from 1850 to 1864 quarterly, daily means of all stations in correspondence with the physical observatory.

Annalen des physikalischen Central-Observatoriums, (Russian and German,) for 1865, 1866, 1867, 1868, 1870, and 1871, tri-daily means of the meteorological elements. No magnetical observations.

Repertorium für Meteorologie, edited by the geographical society, redacteur, Kamtz, 1858 to 1863; a very important source of information; valuable contributions by Kamtz and other scientific men.

Repertorium für Meteorologie, edited by the academy of sciences, redacteur, Dr. Wild, containing works on the climate of Russia by him and his assistants, appears since 1870 irregularly.

Wesselovki's "*O klimate Rossie*," (on the climate of Russia,) 1857. A very important source of information.

The works of the geographical society contain a great deal of information, especially some of the older volumes of the memoirs, (Sapiski,) and the year 1871 of the "Jsvastia." A new volume of the memoirs now in print is devoted entirely to meteorology. The publications of the Caucasian and Siberian branches of the society should also be mentioned. The only volume edited by the new Orenburg section, contains an important contribution by Mr. Ovodof on the winds of Orenburg.

The *Bulletin de la Société des naturalistes*, &c., of Moscow, contains meteorological observations of Moscow from 1841 to 1855, and from 1861 to 1872, as also meteorological contributions of a more general kind. *Mediko-Topograftscheski* collection, edited by the medical department of the interior, two vols., 1870 to 1872. The "*Zeitschrift der österreichischen Gesellschaft für Meteorologie*" contains many papers relating to the climate of Russia. I mention only the tables of temperature in the year 1870, Nos. 10, 14, and 15.

The Bulletin and the Memoirs of the Academy of Sciences of St. Petersburg contained much information in former times; for example, Abich's contributions on the Caucasus, in the years 1849 and 1850. Since the foundation of the "*Repertorium für Meteorologie*," in 1870, the meteorological contributions appear there.

The important works of Dove on temperature, of Buchan on mean pressure and winds, of Coffin, on the winds of the northern hemisphere, published by the Smithsonian Institution, as also Hann, "*Untersuchungen ueber die Winde der nördlichen Hemisphäre*," contain valuable information about Russia.

The publications of the universities (Utschenija Sapiski, Jsvastia, &c.) contain much information, especially in former times, when the centralization of the publications relating to meteorology was not yet begun.

Observations are also often published by newspapers, but it would be too much to mention them all here. The same may be said of some special and old works.

PHENOMENA MANIFESTED IN TELEGRAPHIC LINES DURING THE GREAT AURORA BOREALIS OF FEBRUARY 4, 1872; AND THE ORIGIN OF NORTHERN LIGHTS.

By Professor G. B. Donati,
Superintendent of the Astronomical Observatory at Florence.

[Translated from the Italian for the Smithsonian Institution from the Rivista Scientifico-Industriale.]

It is not necessary for me to give a description of the luminous phenomena manifested during the great aurora of the 4th of February last. So many descriptions of these have been published, that it is very easy for any one to obtain information on the subject. But it will not be unnecessary for scientific purposes to make known the results derived from the observations which during that exhibition of northern lights were made in the various telegraphic offices of this kingdom, and to compare those observations with others made contemporaneously beyond Italy. In doing this I am indebted to the favor of Mr. Commendator D'Amico, director-general of the Italian telegraphic lines, who furnished me with all the observations made by his subordinates on that occasion. From the aggregate of those observations, the following conclusions, I think, may safely be drawn:

The fitful currents and the corresponding perturbations manifested along the telegraphic lines, on the occasion of the aurora of February 4, were greater on the lines extending from east to west than on those extending from north to south. This was the case even when the lines running from east to west were much shorter than those from north to south. In fact, Inspector-General Masi, who was at the office of Bagnara, Calabria, from his accurate observations concludes that the line from Bagnara to Naples, which runs almost entirely along the meridian, and which is the longest of all the lines that meet at Bagnara, gave by the needle of the galvanometer the least deviation of all other lines. And that, on the other hand, the line from Bagnara to St. Euphemia, although shorter, but running almost exactly from east to west, showed the influence of the aurora more than any other line. The same conclusion is drawn from the observations made in Sardinia. On the lines from Cagliari to Iglesias, and from Santa Teresa to Isola Madalena, both very short lines and running from east to west, the perturbations were greater than on the long lines from Santa Teresa to Cagliari, both the latter lines running from north to south. This fact had been noticed by General Masi and entered in his minutes on the exhibition of the aurora on the 24th of October, 1870, and was also observed by Messrs. Sureau and H. Tarry along the French lines.*

The changes of direction as well as the changes of intensity which the currents that ran over the telegraphic wires underwent, were very great during the aurora. The perturbations produced by the aurora began to be noticed on the Italian lines at 4 o'clock 30 minutes p. m. of the 4th. The maximum of the current manifested itself at 6 o'clock 31 minutes, and in that moment the current changed its direction suddenly. Another maximum somewhat less than the preceding manifested itself at 6 hours 37 minutes. At 6 hours 52 minutes the needles of the galvanometers remained stationary for about 3 minutes. Toward 8 p. m. the perturbations lost much of their intensity, and after this no perturbations took place intense enough to obstruct the transmission of dispatches. Notwithstanding this, the luminous phenomena, taken as a whole, though very variable, were not less splendid from 8 to 10 than they had been from 6 to 8. Mr. Masi in his account of the phenomena states as follows: "Looking at my compass, and at the same time at the luminous phenomena, I observed that the deflection of the compass increased with the increase of the luminosity at the northwest and decreased with its decrease." Mr. Masi's remark of the correspondence between the deflection of the needle of the compass and the luminous variations of the aurora in the northwest may be true, but it seems to me, from the examination I have been able to make of the various observations, that the intensity of the luminous phenomena, considered as a whole, was not proportionate to the amount of the perturbations. Indeed, I think that the magnetic perturbations on the telegraphic lines preceded in time the luminous phenomena.

Mr. Masi was led by his observations to think that, on the telegraphic lines which were situated much above the level of the sea, the phenomena produced by the aurora were manifested sooner and with greater energy than on lines less elevated. And also that on the latter lines the phenomena exhibited themselves later and with less intensity. Mr. Masi, however, adds that we have not a sufficient number of observations to consider this as an established fact, but that it deserves attention in the future.

The time given above is mean time at Rome, and it would be very important to ascertain whether in other lines, differing considerably in longitude from the Italian lines, the same phenomena manifested themselves, and exactly at what time. Mr. H. Tarry, who attempted to ascertain this circumstance, says that the magnetic perturbations which took place on the telegraphic lines manifested themselves at the same time in Italy, France, and America, within perhaps one minute's difference.†

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* Comptes-rendus de l'Académie des sciences, Vol. LXXIV, page 484.

† Comptes-rendus, Vol. LXXIV, page 519.

But the facts on which he bases his conclusion seem to me too general and too few, and that we require more particular and more numerous observations before accepting his statement as that of an established fact. Mr. Tarry also adds that "in the telegraphic line from Brest to Paris, from 5h. 55m. to 6 o'clock p. m. (Paris time) there were two very singular waves. The deflection of the needle at first increased progressively from 0° to + 60°. Then there was for one minute a firm adherence of the armature of the telegraphic instrument, with persistent deflection. After this the needle went gradually down to 0, then up to + 60°, where it remained one minute. At six it jumped suddenly from + 60° to − 60°.[*]

I have tried to ascertain whether in the interval of time which corresponds to between 5h. 55m. and 6 o'clock, mean time of Paris, there were any observations made in Italy, in order to compare them with those made in France, and I find that from the observations made at Rome by Messrs. Perelli and Gotti, on the line from Rome to Milan, and from those made at Florence by Messrs. Donalisio, Guidi, and Gabrielli, on the line from Florence to Turin, the following table can be constructed:

Line from Rome to Milan.[†]

Mean time of Paris.			The needle of the galvanometer, at 1000 turns.		
From	5^h 55^m	to 5^h 57^m,	moves gradually from.........	− 62°	to + 78°
	5 57	5 57.5,	passes rapidly from...........	+ 78	− 50
	5 57.5	5 58,	" " "	− 50	+ 73
	5 58	5 58.5,	" " "	+ 73	− 65
	5 58.5	5 59	almost stationary between....	+ 73	− 65
	5 59	6 00.5,	rushes over zero to....................		+ 60

Line from Florence to Turin.

From	5^h 55^m	to 5^h 56^m,	oscilates and goes rapidly from	− 80°	to + 80°
	5 57		moves rapidly from...........	+ 80	− 60
	5 58		" " "	− 60	+ 75
	5 58.5		moves from......................	+ 75	− 65
To	6 00		almost stationary towards.....	− 70	
			then jumps violently to..................		+ 10

In comparing the preceding observations with those reported by Mr. Tarry, it seems as if we may conclude that both in Italy and in France from 5h.55 to 5h.57 (mean time of Paris) there was a gradual movement of the needle; that after this there occurred sudden leaps, and that at 6 o'clock the needle remained stationary for about one minute; after this rest the needle moved violently.

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[*] Comptes-rendus, Vol.LXXIV, page 484.

[†] The line from Rome to Milan passes through Foligno, Florence, Bologna, and Piacenza. The line from Florence to Turin passes through Empoli, Pisa, Spezia, Genoa. The time of the Italian observations are reduced to mean Paris time, by subtracting 40^m. from the time indicated by the observers of Rome and Florence. The observations made at Rome are preceded by the following notice. It being known on which side the needle is deflected when Rome sends a positive current, the deflection observed on the opposite quarter is marked thus, (+) and that on the same quarter is marked thus (—.) The resistance of the galvanometer used in Florence was 101, and that used at Rome 104 Tiemens units.

Mr. Tarry reports that at 5h.28m the needle jumped in France from — 40° to + 60°. At that time the galvanometer had not as yet been used by the inspectors at the office of Rome, but I find that the needle of the common compass used by telegraphists jumped in Rome from + 20° to — 22° at 5h.27m. Mr. Tarry also reports that at 5h.34m the needle of the galvanometer moved suddenly in France from — 40° to + 50; and I find that the needle of the common compass at Rome moved from + 36° to — 26° between 5h.30m and 5h.37m.

No comparison can be instituted with the observations made in Florence during the the above-mentioned time, for observations in that city commenced later. They are all given in mean Paris time.

Mr. Coumbary, director of the observatory at Constantinople, says that on the lines of Turkey, toward 7h.35m the current was reversed and became positive, showing great intensity. Judging from the whole of his remarks, it appears that at the above-mentioned time the greatest perturbation occurred, which manifested itself on the Turkish lines.* I have already said that the Italian lines had reached their maximum at 6h.31m, (mean time of Rome;) if the time stated by Mr. Coumbary is given in mean time of Constantinople, (as is presumable,) then the greatest perturbations on the Turkish lines manifested themselves at 6h.29m mean time of Rome.†

Mr. Coumbary says that at 9 o'clock (7h.54m mean time of Rome) telegraphic communication was resumed in Turkey. It has been already mentioned that in Italy perturbations on the lines became much weaker toward 8 o'clock, (mean time of Rome.) So that it seems that the great perturbations ceased contemporaneously in Italy and in Turkey. From what has been stated it appears that we may conclude with Mr. Tarry that the perturbations on the telegraphic lines took place, as a general rule, simultaneously. On this important point, however, more extensive researches are needed, and with more particulars than have hitherto been given; inasmuch as the perturbations on the telegraphic wires followed each other almost continuously, and errors, however small, in the times noted, or in the deflections observed, might make a coincidence appear where there was really none.

To prove the *general simultaneousness* of the electrical perturbations which manifest themselves in the electrical telegraphs in auroral manifestations, would be the much more important, inasmuch as it appears sufficiently proved by experience that the luminous phenomena proceeding from auroras are not at all simultaneous, but manifest themselves first in the more eastern countries, and then in the western. In support of the above view, Professor Olmstead cites many facts in a learned essay, published in the contributions of the Smithsonian Institution of America. Mr. Tarry also has noted a similar fact in the great aurora of February 4, 1872, while comparing the times in which the luminous phenomena were seen in Europe with the times in which they were seen in Duxbury, near Boston.*

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* Comptes-rendus, Vol. LXXIV, page 828.

† Constantinople is east from Rome about 1h.06m.

To this I can add that the Italian consul of Cyprus addressed a letter to his excellency our minister of foreign affairs, which was kindly communicated to me, from which it appears that the luminous phenomena of the aurora of February 4 last were very conspicuous at Cyprus, that they became feebler toward 10 o'clock, (local time,) and after that disappeared almost entirely. At Paris, also, the luminous phenomena of the same aurora were very vivid till 10 o'clock, (local time,) then became much weaker, and disappeared almost entirely. Now, as Cyprus is about two hours east of Paris, it follows that in absolute time the luminous phenomena of the aurora ceased at Cyprus two hours before they disappeared in Paris. If it were not so, and the light of the aurora borealis had been very bright at Cyprus at the same time that it appeared very splendid in Paris, instead of beginning to decrease in the latter place at 10 o'clock without any further increase of brightness, it ought to have continued in its splendor till after midnight.

Now, how can we explain the fact that the luminous phenomena of the aurora borealis appear first in the east and after in the west? The theory that the aurora is nothing else but a slow electrical discharge, which takes place between the upper and the lower strata of our atmosphere, is well known, generally admitted, and confirmed by the beautiful experiments of De La Rive. On this point there can be very little doubt at present. But is this a complete explanation; that is, does it give a reason for all the circumstances which accompany the aurora borealis? Besides the circumstance that the luminous phenomena of the aurora move, so to speak, from east to west, there is another very important one which must not be overlooked when we are seeking for an explanation of these phenomena as satisfactory as we can obtain. The late researches made by Professor Loomis prove that in latitudes which are not very high the number of auroras and their luminous intensity has a maximum and a minimum about every ten years; and this fact is also confirmed by an examination which I have undertaken of an extensive series of observations existing in this observatory, in which the exhibitions of auroras are accurately recorded. Although the theory which regards the aurora borealis as the result of slow and prolonged discharges of electricity is *physically* complete, and explains fully the electrical and luminous phenomena, it does not seem of itself to give a satisfactory reason either for the periodicity of the auroras or of the successive progress of the phenomena from east to west. That theory may still be adopted as general exposition of the phenomena, although it may require to be supplemented with additional hypotheses. It seems to me that this can be done by admitting, with Sir John Herschel, that between the sun and the planets there may be an interchange of electrical currents. In such a case these currents will be at different times more or less intense, according to the position and the distance which the planets occupy in space with respect to the sun and to each other; and on this account the resulting phenomena will be subject to a periodicity. If we admit that between the different bodies of our system there is a continuous exchange of electrical action, that is, if we admit that there exists a cosmical electricity, the former may combine with the natural electricity of the earth, and produce almost constant auroras at the poles, where the terrestrial magnetism is more energetic; then, if from any cause whatever the cosmical electricity increases, the northern lights may increase correspondingly, so as to become visible even in places very distant from the poles.

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* Denison Olmstead, Smithsonian Contributions January, 1855, pp. 44–45; H. Tarry, Comptes-rendus, Vol. LXXIV, p. 549.

If the existence of cosmical electrical currents is admitted, we may also imagine that in certain cases an electrical discharge takes place toward the sun or from it; in such a case we can conceive that certain phenomena can occur only in such places as have a certain direction and a certain position with respect to that discharge. Consequently such phenomena will make themselves visible successively under the different meridians, according as, by the diurnal motion of the earth, they come to occupy successively the same position and the same direction with respect to the discharge which we have imagined. It is true that we have no direct proof of these cosmical electrical currents, but it is a very old idea, put forth by Galileo, Kepler, and many other philosophers, that the sun and the planets may be magnetic bodies, and why not electrical as well as the earth? and if this is the case, (which seems very natural,) it may also be admitted that through that ether which is generally admitted as filling the universe, there may be an interchange of electric currents between planet and planet, and between the planets and the sun.

Sir John Herschel, in a note at the end of the fifth chapter of his astronomy published in 1833, writes as follows:

"Electricity traversing excessively rarefied air or vapors gives out light, and, doubtless, also heat. May not a continual current of electric matter be constantly circulating in the sun's immediate neighborhood, or traversing the planetary spaces, and exciting, in the upper regions of its atmosphere, those phenomena of which, on however diminutive a scale, we have yet an unequivocal manifestation in our aurora borealis? The possible analogy of the solar light to that of the aurora has been distinctly insisted on by my father, in his paper already cited. It would be a highly curious subject of experimental inquiry, how far a mere reduplication of sheets of flame, at a distance one behind the other, (by which their *light* might be brought to any required intensity,) would communicate to the *heat* of the resulting compound ray the *penetrating* character which distinguishes the solar calorific rays. We may also observe that the tranquillity of the sun's polar, as compared with its equatorial regions, (if its spots be really atmospheric,) cannot be accounted for by its rotation on its axis only, but *must* arise from some cause external to the sun, as we see the belts of Jupiter and Saturn, and our trade-winds, arise from a cause external to these planets, combining itself with their rotation, which *alone* can produce no motions when once the form of equilibrium is attained.

"The prismatic analysis of the solar beam exhibits in the spectrum a series of fixed lines, totally unlike those which belong to the light of any known terrestrial flame. This may, hereafter, lead us to a clearer insight into its origin."*

Though science cannot prove directly that electrical currents travel through the planetary spaces, yet there exist not a few data which seem to indicate sufficiently that certain phenomena which take place in the sun and the planets depend on the distance and the position of the latter with respect to the sun and with respect to themselves.

Galileo, in one of his letters, says: "The fact that the spots of the sun are on that belt of the solar globe which is under that part of the heavens through which the planets travel, and nowhere else, is an indication that those planets may have something to do with that result."† This suggestion of Galileo, that the phenomena of the solar spots may have some connection with the position of the planets, has remained unnoticed for nearly two centuries and a half, until lately new facts have come to light which indicate its importance.

In 1859, Mr. Wolf undertook to investigate whether the phenomena of the solar spots varied with the distances of the planets from the sun, and he reached results which generally tend to prove that, with the change of those distances, and especially with those of Jupiter, the number of solar spots also changes within certain limits. Mr. Carrington, in his work on the solar spots, published in 1863, presented the results of a similar research, and having determined the number of solar spots observed every year from 1750 to 1860, he compared them with the distances of Jupiter from the sun, and concludes that according as Jupiter moves away from the sun the number of solar spots increases, and when Jupiter approaches the sun the number of spots decreases.

Professor Loomis has lately announced that the decennial period of the solar spots, instead of corresponding with the distance of Jupiter alone, has a nearer and more regular correspondence with another period which can be found by comparing together the movements of Jupiter and of Saturn. These two planets, in fact, occupy in space such positions that every ten years Jupiter is either in conjunction or in opposition with Saturn. Other relations seem to exist between the solar spots and the positions of the planets. Messrs. De La Rue, Stewart, and Loewy, in a series of essays, which they published together from 1845 to 1848, concerning the physics of the sun, have shown that the spots of this luminary (irrespective of their number) increase in size when, by means of the solar rotation, they are carried farthest from the place which Venus occupies in space, and that they diminish in size when they aproach that planet. Mars also contributes to the increase and decrease of the size of the solar spots in the same way that Venus does, but his influence is less powerful than that of Venus, perhaps on account of his greater distance from the sun. Mercury seems to possess somewhat of a similar influence, which, however, shows itself less distinctly on account of the rapidity with which he moves round the sun. The position as well as the size of the solar spots depends on the place occupied by the planets in space. When Jupiter and Venus, in their orbital motions, cross the plane of the solar equator, then the spots appear nearer the same equator; and, on the contrary, when these two planets occupy positions distant from the sun's equator, then these spots also appear farthest from the same equator.

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* A remarkable prediction, well worthy of attention as an evidence of the sagacity of this eminent savant to whom it is due.—J. H.

† Lettera seconda di Galilei a Marco Valseri; nuovamente pubblicata dal Prof. P. Volpicelli. Roma, tipografia delle Belle Arti, 1860.

From some observations made on the occasion of the solar eclipse, December 22, 1870, Professor Serpieri concludes that the protuberances which emerge from the sun during the eclipses are directed toward the planets. In fact, he observed one protuberance bending toward Saturn. Serpieri's conclusions seem confirmed by other observations made by Professor Tacchini, who, on the 27th May, 1871, saw, while the sun was shining, one of those protuberances, which seemed directed toward a group of planets. But if the number, the position, and the size of the solar spots depend on the positions of the planets, terrestrial magnetism must be dependent on the same; for it is established, with considerable certainty, that the phenomena of the variations and perturbations of all the magnetic elements are also connected with the solar spots. Consequently, (to resume the subject which more especially concerns us,) the auroras also may somewhat depend on the relative positions of the planets, and therefore they are subject to periodicity, and also advance from east to west in the way and for reasons already mentioned.

[The remainder of the paper of Professor Donati is occupied with a defense of his claim to the foregoing hypothesis, which, being of no interest to the readers of this report, is omitted. It is proper, however, to remark that, in this translation, the expression electrical currents has been substituted for the phrase magnetic currents, used by the author. The reasons for this change are, because this is the term used by Sir John Herschel in the quotation from his astronomy by Professor Donati, and furthermore because there is, strictly speaking, nothing in the phenomenon of magnetism to which we can apply the term current, or a transference of magnetism from one body to another, as is the case in the phenomenon of an electrical discharge. If we rightly understand it, the theory given in this essay by Professor Donati is, that the sun and the planets, including the earth, are electrical, and that electrical discharges may take place from one to the other. This hypothesis has the support of the fact that the earth is known to be a great charged conductor, permanently electrified negatively, and that the intensity of this electrical condition is varied from time to time by perturbations produced by terrestrial, and, possibly, by cosmical causes. There is another theory advanced by the distinguished physicist Balfour Stewart, professor of natural philosophy in Owen's College, Manchester, according to which the sun and planets, like the earth, are great magnetic bodies, with opposite poles of greater intensity, subject to perturbations from cosmical or special causes, and that these poles, acting by induction on the magnetism of the earth, give rise to the movements of the magnetic needle, and to the induced electrical currents to which the appearance of the aurora is attributed.

There is still another hypothesis proposed by M. Becquerel as to the origin of the electricity of the atmosphere and of the aurora polaris which has been modified by M. Faye. This hypothesis, like that of Herschel, refers the electricity of our atmosphere to the sun, and founds the conception of it on the constitution of that luminary as revealed by modern spectroscopic discoveries. From these discoveries the following conclusions have been deduced:

1st. The sun consists of a nucleus, relatively obscure, having a temperature excessively elevated, and which is in a fluid state at least to a certain depth.

2d. This nucleus, on account of the cooling by radiation, is surrounded by a terminated envelope which has the constitution of a gas with particles floating in or disseminated through it, of a solid or liquid nature. These minute particles radiate energetically as do the particles of carbon in the flame of burning gas, and give to this envelope, which is called the photosphere, its name and its luminosity.

3d. Above the photosphere is found the chromosphere, formed principally of a thin layer of incandescent hydrogen. To this stratum apparently belong the protuberances which of late years have excited so much interest.

4th. Lastly, above the photosphere is found a fourth atmosphere, discovered during the last solar eclipse, which has been named the coronal. This, which appears to be extremely rare, is very distinct from the chromosphere, although formed of the same gas, namely, hydrogen.

The foregoing propositions are considered as facts immediately deduced from the phenomena and well-established physical principles. The hypothesis as to the origin of this condition is that the nucleus of the sun, as seen through the spots as a darker mass, is in reality much hotter than the photosphere—so hot, indeed, as to prevent the union of the oxygen with the hydrogen and the vapor of other substances whose presence is manifest by the spectroscope. That the spots themselves are craters of eruptions through which the dark gases issue into the chromosphere, and being reduced in temperature combine, giving rise to intense light on account of the vibrations of the solid or liquid particles produced by this union. The hydrogen, being the lightest of all the gases, will be driven farthest from the center of the sun by its expansion, and will appear, as it is seen to do, in the form of the protuberances, which are found to consist of this gas in a pure but highly attenuated condition. Now, although neither evaporization nor condensation of vapor produces electricity, chemical action does in a high degree; and, therefore, at every eruption of matter from the lower into the upper stratum of the sun, there must be a great development of positive electricity, the nucleus being negative. Whatever influence this electricity may have on the electricity of the earth and the appearance of the aurora must be manifest at the time of the appearance of spots on the sun, and hence we have an hypothetical cause for the connection of two phenomena which have been established by Woolf and others.

But the question occurs, how does the variable electrical condition of the sun affect that of the earth? Two answers may be given to this question: First, it may affect it by induction, or action, at a distance. The redundant electricity of the surface of the sun, acting by repulsion on the electricity of the earth, thus disturbs its equilibrium. But if the nucleus of the sun is electrified minus to an equal degree as the outer spheres are electrified plus, the two resulting actions would neutralize each other, and the effect at the distance of the earth would be nothing.

M. Faye gives another suggestion as to the means by which the electricity of the sun affects the electrical condition of the earth. He claims to have found a repulsive force in the sun, of which he considers the existence strikingly manifest in the gigantic phenomena of comets. This force, unlike that of attraction, is not proportional to the mass but to the surface of the body repelled; it is insensible in the case of dense bodies such as the planets, while it exerts very marked effects upon bodies which are greatly rarified, such as the nebulosity of comets and the outer hydrogen of the sun. A small portion of this latter, according to M. Faye, at every eruption is driven off into space, carrying with it its charge of plus electricity, which extends to all the planets, and in uniting with the ozone in the higher regions of the atmosphere may be converted into the vapor of water, while the electric charge produces the electricity of the higher atmosphere of our earth. The quantity of hydrogen thus lost by the sun is too minute to be sensible by any of our measurements during the historic period. There is one phenomenon connected with this subject which is not clearly explained by this hypothesis, and that is the apparent fact that the appearance of the aurora and the disturbance of the magnetic needle are almost, if not quite, simultaneous with the commotions in the sun. This would indicate an inductive action analogous to attraction in the instantaneousness of its action at a distance.

A similar hypothesis has been proposed by Professor Newton, of Yale College. According to this the corona is made up of matter in the act of streaming off from the sun, instead of being a permanent solar atmosphere, or a mass of revolving meteors. The explosive actions, which are the most probable causes of the spots, may, perhaps, furnish the luminary matter, which, dispersed at intervals by reason of the varying action of the planets as it flows away into space, forms the *corona*, with its accompanying radiations and streamers, visible in the total eclipses. The zodiacal light is also made of the streams of particles flowing away from the sun under the operation of solar repulsion.

In the American Journal of Science, (March and July, 1855,) Professor Newton explains the irregular perturbations of the magnetic needle by electric currents developed in the upper atmosphere (or photosphere) of the earth by the arrival of the solar matter, which is probably the substance of terrestrial auroras.

Whatever truth may be in these speculations, they indicate a tendency in the scientific mind of the day to adopt the conclusion that many of the phenomena which have heretofore been considered entirely of a terrestrial character really belong to the solar system; that not only are disturbances of the magnetism of the earth connected with commotions in the sun, but that cyclones and other violent movements of our atmosphere have a similar relation to the central luminary.—J. H.

ETHNOLOGY.

THE TROGLODYTES, OR CAVE-DWELLERS, OF THE VALLEY OF THE VÉZÈRE.

BY M. PAUL BROCA.

An Address delivered before the French Association for the Advancement of Science.

[Translated from "La Revue Scientifique," November 16, 1872, for the Smithsonian Institution.]

LADIES AND GENTLEMEN: Impressed by the splendor which surrounds me, and by the sight of this large audience, I am impelled to render homage to the beauty and intelligence which have prepared so brilliant a reception for the French Association. The members of the society have reason to congratulate themselves upon having chosen Bordeaux for its first session.

Our institution is one that appeals to general interest. Although it has originated entirely in private enterprise, it rests upon bases which assure its continuance, and it cannot fail to survive the struggle which may be maintained for years against public indifference. Yes, although our *début* should be greeted with coldness and neglect, we would persevere, for we consider the diffusion of knowledge as an important element of the greatness of nations, and surely the necessity of this diffusion has been rendered palpable by the recent disasters which have shown the danger of extreme intellectual centralization. Convinced of the utility of our objects, undismayed by obstacles, and undiscouraged by apparent defeat, we will renew our sessions year by year, increasing in numbers as we gradually enlist recruits, and assured that in a country like ours success, however long deferred, must sooner or later crown our efforts.

For the success of the first session, which has far surpassed our hopes, thanks are due to my esteemed colaborers, MM. Broca and Girondin; also, to the distinguished gentlemen of the local committee, especially Professor Azani, the intelligent and indefatigable secretary.

The subject of my discourse is the troglodytes, or cave-dwellers, of the Vézère, that fossil population whose subterraneous dwellings we are about to investigate.

Their existence dates back to a remote antiquity. We do not know their names; no historian has mentioned them, and it is only eight years since the first traces of them were discovered, and yet in some respects we are better acquainted with them than with certain celebrated nations of classic renown. We know their mode of existence, their arts, their industries, many details of their lives. Does not such knowledge constitute the real history of nations, a history more interesting than that of their battles, their conquests, and even their dynasties?

How does it happen that we know so much about people who have left no trace in the memory of man, and whose existence, even twenty years ago, was deemed impossible? Are they children of romance, like the celebrated troglodytes of Montesque? On the contrary, nothing is more real than our troglodytes; nothing is more authentic than their annals. In the caves they inhabited, or in which they deposited their dead, we find the residue of their feasts, the products of their industries and their arts, and the remains of their bodies. These are the books in which we read their history; these are the documents which have resuscitated their past.

Several savans have taken part in these investigations; among them Christy, the Marquis of Vibrage, M. Falconer, and our two colleagues, MM. Louis Lartet and Elie Massénat, deserve respect; but one name eclipses all others—that of the founder of human paleontology, Edward Lartet.

We with reason admire Cuvier, who, in his study of fossil bones, succeeded in restoring the successive fauna of the geological periods; also Champollion, who, with so much sagacity and patience, deciphered the hieroglyphical monuments of Egypt, but not less admirable in his important labors was Edward Lartet. His field of investigation lay between that of Cuvier and that of Champollion, and shared in both. He revived human associations in those paleontological periods in which Cuvier found only extinct brute animals; he discovered the history and the chronology of the ancient man, the contemporary of the mammoth, as Champollion discovered that of the architects of the great pyramids. These three men are the glory of French science. They were initiators; they founded schools. Their disciples and followers have but widened the paths they opened, and although foreign savans have made great progress, they do not forget that to France belongs the honor of having led the way.

I.—DETERMINATION OF TIME.

Before discussing a population it may be well to assign it a place in time. But in this case ordinary chronology is not applicable, for we have to do with periods of incalculable length. Since the time when our troglodytes were in existence great changes have taken place in climate and fauna. These were produced without revolution, without violent action, by the gradual influence of insensible causes, which are still in exercise at the present day; and when we think that these causes, during the course of the centuries known to us, have produced only changes almost inappreciable, we may form some idea of the immense duration of what is called a geological period.

It is not by years, centuries, or thousands of years, that we can measure these immense periods; it is not by figures that we can express these dates; but we can determine the order in which these geological periods succeeded each other, and the sub-periods of which each was composed.

These are the dates of the history of our planet, and the elements of what Edward Lartet called the chronology of paleontology.

I need not speak of the Primary and Secondary geological periods, as they are foreign to the chronology of man, since he did not then exist; nor need the Tertiary period scarcely more arrest our attention. It is true that the discoveries of M. Desnoyers in the Pliocene chalk-pits of Saint Prest, show the existence of man as early as the end of the Tertiary period in company with the southern elephant, the rhinoceros leptorhinus, and the great hippopotamus; he even lived, according to the Abbé Bourgeois, during the Miocene period, contemporary with the mastodons, the predecessors of the elephants; but the latter fact is doubtful; and as to the Tertiary man of Saint Prest, he was so much anterior to our troglodytes, that he need not figure in our chronology. It is sufficient in the determination of our dates to commence with the beginning of the Quaternary period.

The end of the Tertiary period was distinguished by a remarkable phenomenon, the causes of which are still imperfectly known. The northern hemisphere was gradually cooled. Immense masses of ice descended the sides of the mountains, into the valleys and plains, and covered a large part of Europe, Asia, and North America, and the temperature of our zone, previously torrid, gradually became glacial. This cold period, called the Glacial period, was excessively long. After reaching their utmost southern extent the glaciers receded considerably, and then advanced again without attaining their previous limits. This was the last phase of the Tertiary epoch. The Glacial period came to an end. The gradual increase of temperature melted the ice, and the Quaternary period commenced.

The masses of snow constituting the glaciers, which had been accumulating for years, produced, by their melting, immense floods, which bore upon their powerful waves the *débris* of the mountains, inundated the plains, plowed the surface of the earth, excavated valleys, and left in their passage large deposits of sand, clay, and bowlders. From this period, called the Diluvian, date our present rivers, which give us, however, but a faint idea of their former magnitude. In their now limited and unchanging channels they transmit only the water which descends day by day from the clouds, while the freshets occasioned by the melting of winter snows are of very little moment compared with those immense inundations formerly produced when the heat of summer melted not only the annual snows, but a part of the ancient glacier.

The great power of the floods of water was especially remarkable during the first part of the Quaternary period. It became less and less until the glaciers were reduced to their present limits, and the temperature to its present degree. It was at this time that the phenomena of great changes ceased, and the Quaternary period came to an end. Since then, although mountain torrents carry with them sand and pebbles, and sometimes tear from the sides of the valleys masses of considerable size, the rivers and smaller streams bear with them only fine particles of earthy matter, which give rise to alluvial deposits.

The time which has elapsed since the end of the Quaternary period bears the name of the present period, and the strata formed during its continuance are called recent deposits. They are recent compared with those of the Quaternary period, but not so when estimated by our ordinary chronology, since in most cases their formation has required thousands of centuries.

These preliminary ideas enable us to comprehend the essential facts which determine the dates of human paleontology. These dates are established, in the first place by pure geology, in the second by paleontology, in the third by prehistoric archæology.

The geological dates are principally inscribed in the valleys and in the plains, where the great floods of water of the Quaternary period have left deposits in the form of beds, more or less regularly stratified. If these strata have remained undisturbed, they are found superposed according to age. The oldest lie lowest, and are called the lowest levels; above them lie the mean levels, which are posterior to them, and which in turn are covered by the upper levels, formed during the latter part of the Quaternary period. Finally a stratum, more or less thick, of recent formation, consisting of alluvions, peat, &c., almost always covers the Quaternary deposits.

These different strata are not everywhere found in complete series, and the nature of the elements of which they are composed varies more or less with the locality; but I cannot now enter into details. I can only give a general idea of the way in which, by the study of the superposition of these beds, that is to say, their stratification, the relative age of the various deposits, recent or Quaternary, is determined.

In this determination we first apply to geology. Thanks to the data it furnishes, we know the age of the animals whose bones are found in the different strata; these animals in turn serve to establish the periods, and also the dates of certain formations or partial deposits which do not form a part of a complete and regular stratification.

Of the animals living at the commencement of the Quaternary period, some, like the mammoth, only exist now as fossils; these are the extinct animals; others, like the fox, have disappeared from our locality, but still live in other parts of the world; these are migrated animals; and others, like the horse, continue with us to the present day; these are called persisting animals.

Extinct animals abounded in the first part of the Quaternary period. Some of them were immense mammals with terribly powerful limbs, beside which man, naked and feeble, was of little account. Such were the large bear of the caves, (*Ursus spelæus;*) the great lion, also of the caves, (*Felis spelæus;*) the amphibious hippopotamus, (*Hip. amphibius;*) the rhinoceros, with chambered nostrils, (*Rh. tichorhinus;*) the ancient elephant, (*Elephas antiquus;*) and, above all, the giant king of this fauna, the mammoth, (*Elephas primigenius.*) Of the other extinct species of the period it would be superfluous to speak. The reindeer and several other migrated animals are found in this fauna, but are rare, and a large number of persistent species had already made their appearance.

Of all these animals, the most remarkable, the most powerful in strength and numbers, was the mammoth. Protected from the cold by a thick covering of fur, and provided with formidable means of defense against its enemies, it prospered and multiplied; it spread and dominated over all the earth, so that the first part of the Quaternary period, which corresponds with the lower levels of the valleys, may well be called the age of the mammoth. At that time every condition was favorable to the prosperity of this animal. But in time there were changes which led to its decadence. An elevation in the temperature allowed the extension of numerous herbivorous species hitherto restrained in their development. The reindeer, the horse, the ox, and the bison multiplied. These, his powerful rivals, disputed with the mammoth his vegetable nutrition, and with him commenced the struggle for existence. Already he saw opposed to him the power of man, which under the ameliorated conditions of climate was sufficient to declare war against him, and finally this same climate which was so favorable to his enemies and rivals became directly prejudicial to his organization, intended for a boreal temperature.

Thus the mammoth, once so important in the first part of the Quaternary period, commenced to decline. He ceased to be the predominant species of the fauna, and as to the other animals which formed his ancient cortége, many yielded with him to the destructive influence of the changed temperature, and decreasing in numbers we see them slowly, one after the other, disappear. Some, it is true, survive, and may prolong their existence to the end of paleontological time, but their reign is over.

Thus about the middle of the Quaternary period there was an intermediate age, corresponding with the mean levels of the valleys; an age when several species contemporary with the mammoth had already become extinct, and others, which had almost disappeared, were represented by only a few individuals, while animals better adapted to the changed conditions prospered. Prominent among the latter was the reindeer, (*Cervus tarandus*,) but it was not until the following period that it attained its full importance.

The fauna of the intermediate age has no especial paleontological characteristics. It is distinguished less by the nature of the species than by the relative proportion of their representation. Certain animals of the age of the mammoth no longer existed, but others were found here and there. The mammoth, although reduced in numbers, had not yet become rare, while the reindeer, the stag, the horse, and the ox had become common.

This intermediate age gradually yielded to the third and last age of the Quaternary period. When the strata of the upper levels began to be formed, the animals we call extinct had almost entirely disappeared. A few rare specimens of the mammoth still survived. Still more rare was the great Irish stag (*Megaceros hibernicus*) and the large lion of the caves. The rest of the fauna had changed but little. The reindeer, however, had increased to a most extraordinary extent, and the third period is deservedly called the *age of the reindeer.*

It is not only in the existence of the reindeer that this period differs from that of our day. In company with the reindeer lived in our still cold region a number of animals to whom frost and snow were congenial elements, and who could not exist in temperate climates. As the temperature approached its present condition, the individuals which upon our plateaus and in our plains represented these species disappeared; but the species themselves, far from perishing, found in a colder climate a more congenial temperature, and have been perpetuated to the present day. Among these species called migratory, some, like the reindeer, the sloth, the musk-ox, have gone toward the north; others, such as the chamois, the goat, the marmot, have not left our zone, but have sought greater altitudes, and have taken refuge in the lofty peaks of the Alps and the Pyrenees.

The disappearance of the reindeer and other migratory species marked the end of the Quaternary period, and of paleontological time. Then commenced the modern period. Our climate, at that time, was probably rather colder than at present, but it was already temperate, and the slight changes it has since undergone have not been sufficient to produce the extinction of species. It is true that the urus, (*Bos primigenius*,) and the aurochs, (*Bison europæus*,) have disappeared from our region, but this must be attributed to the destructive action of man rather than to the effects of climate; and to man, also, is attributable the introduction of certain new species, for the most part domestic. With these exceptions, we may say that since the end of the Quaternary period our fauna has undergone no change, and that the recent deposits contain only actual or living species.

The dates we seek to establish are then determined both by stratography and paleontology. They also rest upon a certain order of facts which to-day constitutes a new science—that of prehistoric archæology.

Man lived in all the periods of which we have just spoken. It does not concern us whether or not he existed in the latter part of the Tertiary period. This Tertiary man does not come within the limits of our present observations, and, besides, it is by no means certain that he existed. But what does concern us, and has been positively proved by Boucher de Perthes, is, that the most ancient strata of the Quaternary period contain evidences of human industry. The knowledge of the use of metals dates, we may say, only from yesterday. But before man possessed these powerful auxiliaries he was not without instruments of labor or means of defense. He fabricated tools and weapons of warfare, out of various hard materials, such as the bones, teeth, and horns of animals, and above all of stone, especially flint, and this is the reason why in the history of man the name of *Stone age* has been given to the whole period which preceded the use of metals.

This age of stone still continues among certain savage tribes, and it came to an end with the most anciently civilized nations at a period only a very little anterior to historic times. It therefore includes almost the entire duration of the existence of humanity. Now, the mode of fabrication, the form and nature of these instruments, necessarily varied during this immense period, with the needs, the kind of life, and the social state of the men who employed them; and when we remember that hard substances like stones may be preserved for an unlimited period in the ground, we comprehend that these remains of human industry constitute ineffaceable records of the past, chronological documents of the utmost importance.

The dates established by prehistoric archæology accord very well, and sometimes coincide, in a most remarkable manner, with those of paleon tology and stratography. Just as certain species of animals have continued from the earliest Quaternary times, so certain forms of flint instruments have been perpetuated through several archæological ages. Such are the elongated pieces of stone, with their two edges sharpened, and one face cut with two sides, while the other has but one, called knives. The small knives of obsidian, still in use among the aborigines of Mexico, and the flint knives, which our ancestors of the Bronze age frequently deposited in their sepulchers, are very similar to those of the age of the mammoth. But this is an exceptional case; in general, prehistoric instruments have from age to age undergone various modifications.

I cannot attempt here to mention, still less to describe, the numerous instruments of each period; axes, knives, points of lances, or of arrows, scrapers, hammers, &c. Geologists frequently, as we have seen, determine and designate an entire fauna by a single characteristic species. So archæologists distinguish the different periods of the Stone age by the instrument the most characteristic of each of them.

A precise determination of these periods and of their number is not possible; for the flint instruments have, during the same period, undergone different changes in different localities, but a general reduction into three has been made by M. de Mortillet of the archæological divisions of the Quaternary period.

1. The most remarkable type of the first Quaternary division is the so-called *Saint Acheul* ax. (See Figs. 1 and 2.) It is of flint, of variable size, always quite large, longer than wide, thick in the middle, sharpened at the edges, with one end pointed, or rather orgival, while the other is rounded; but its most distinguishing characteristic is that its two faces or sides are shaped; these are more or less convex, and more or less symmetrical. This type abounds at Saint Acheul, near Amiens, in the valley of the Somme; hence its name; but it is found in almost all

the deposits of the Mammoth age, and sometimes, though rarely, in less ancient strata.

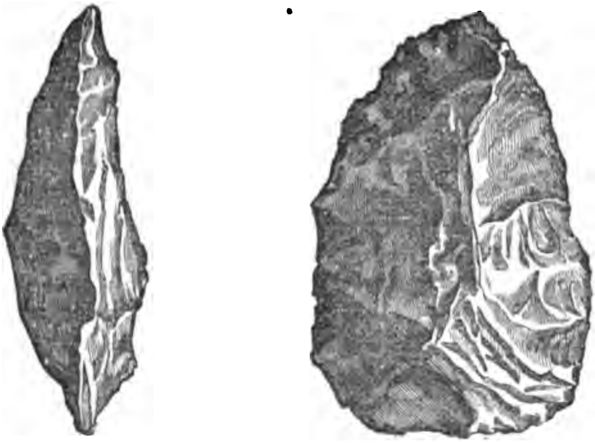


Fig. 2. Fig. 1.

The Saint Acheul type.—Ax with both faces shaped. Fig. 1, view of face. Fig. 2, view of edge.

2. The second division of the Stone age is characterized by the Moustier spear-head. (See Figs. 3, 4, and 5.) This instrument, which was attached to the end of a long lance, differs little in contour from the Saint Acheul ax—is somewhat more pointed, but is distinguished by having only one of its sides shaped. The other was made at one blow which split it from the adjacent stone, and was never retouched. It is therefore not biconvex, like the preceding, but plano-convex, and consequently only half as thick.

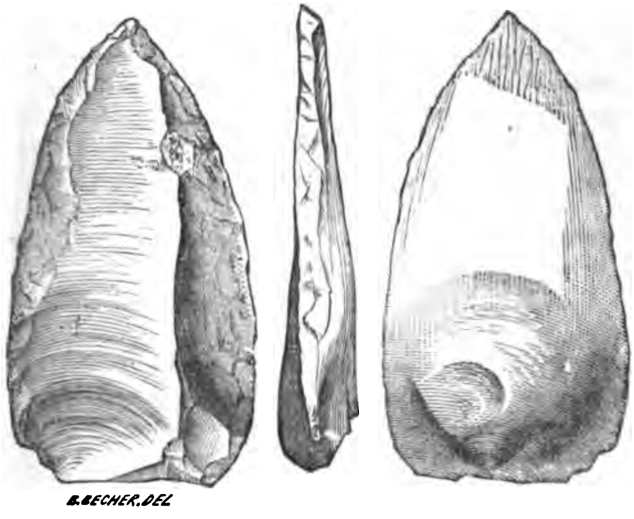


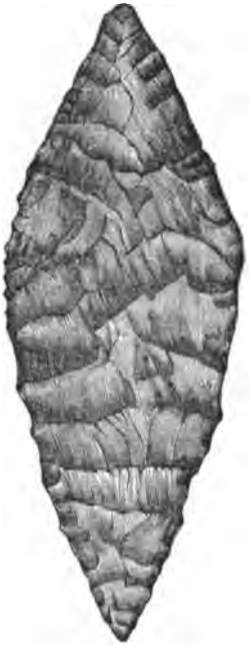
Fig. 4. Fig. 5. Fig. 3.

The Moustier type.—Lance-head shaped only upon one side. Fig. 3, the side not shaped, showing at the base the point of percussion. Fig. 4, the shaped side. Fig. 5, side view.

The Moustier type takes its name from the Moustier cave, where it is very common and where it was first discovered by Edward Lartet and Christy. A few specimens have been found in more ancient deposits, corresponding with the first Quaternary period, and also in more recent deposits corresponding with the latest; but it properly belongs to the intermediate.

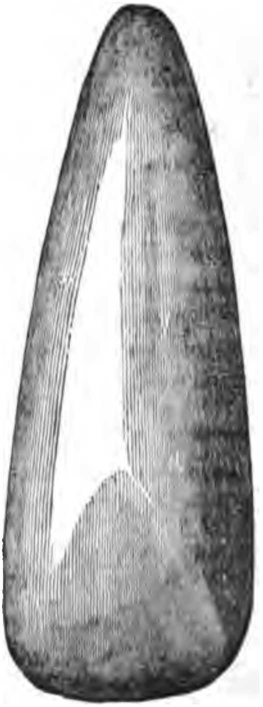
3. In a third period, which corresponds to the age of the reindeer, the flint instrument was perfected. The ends are more pointed, the contour more regular and symmetrical, and the edges have evidently been formed with finer touches. This period of the stone age is distinguished more by the character of the manufacture than by the kind of instrument. The lance-head of Solutré has been generally taken as a type, because only a short time ago the lances from Solutré, in Mâconnais, were the best made instruments which had been found in the Quaternary deposits, (see Fig. 6;) but since then Dr. Jules Parrot, and his brother, M. Philippe Parrot, have found at Saint Martin of Excideuil, (Dordogne,) in a cave of the age of the reindeer, numerous flint instruments much more perfected.

Fig. 6.



The Solutré type.—Point of Solutré lance.

Fig. 7.



The polished ax.

We have now come to the end of the age of the reindeer, and to the commencement of the present period. We now find an improvement in the manufacture of flint instruments, which marks the beginning of a new archæological era. Hitherto these instruments were made by percussion or by pressure; although, it is true, some implements of secondary use were rounded into shape by friction, but the flint tools and weapons were always chipped. In the era upon which we are now entering these implements were made in the same way, but the flint was polished, and the *polished ax*, too well known to need description, became the principal auxiliary of man. (See Fig. 7.)

This ax characterized *the period of polished stone* or the *neolithic period* which terminated the stone age, and consequently lasted until the introduction of the metals.

All the periods which precede the appearance of the polished ax constitute the *period of stone*, also called the archæolithic, or, rather, the paleolithic period.

The various phases of the age of chipped stone succeeded each other progressively, and by almost insensible transitions, like the corresponding geological periods; but the change to the period of polished stone was much more abrupt. Its commencement coincides exactly with the disappearance of the reindeer, that is with the end of paleontological time, and with the beginning of the present geological era. It coincides also with a complete change in the social condition of man, with the domestication of the dog, with the adoption of pastoral life, marked by the domestication of several herbivorous animals, and also with the introduction of agriculture. Thus many centuries passed until the appearance of the bronze, which put an end to the stone age. The length of the period of polished stone was very great; the entire duration of historic time was nothing in comparison, and yet it was immeasurably shorter than any of those which form the age of chipped stone.

We have thus examined the succession of pre-historic ages from the commencement of the Quaternary period, under the triple point of view of stratigraphy, paleontology, and archæology, and we have obtained three series of dates which, if not altogether precise, are sufficiently approximate to form the following table, which may serve as a review:

Stratigraphical periods.		Paleontological periods.	Archæological periods.
Quaternary period.	Lower strata of valleys undisturbed.	Age of mammoth	The St. Acheul ax.
	Median strata	Intermediate age	Lance-head of Moustier.
	Upper strata	Age of reindeer	Lance-head of Solutré.
Present period.	Recent deposits	Actual fauna	The polished ax.

II.—SUCCESSIVE LOCALITIES OF THE TROGLODYTES OF THE VÉZÈRE.

We now possess the knowledge requisite to assign a place in time to the troglodytes of the valley of the Vézère. In their numerous localities not a single polished ax has been found; their industrial implements belong to the age of chipped stone, and are, therefore, anterior to the recent period. They were familiar with the mammoth, fought with him, fed upon him, and even sketched him, and yet in their most ancient locality, at least the most ancient known, the extinct species are rare. Therefore, our troglodytes do not date from the first Quaternary period, or the age of the mammoth. The Moustier locality incontestably belongs to the age we have called intermediate, and which precedes the age of the reindeer, while their other localities descend from period to period until the end of the age of the reindeer. They witnessed then the extinction of the ancient fauna. They did not, it is true, see disappear the last survivor—the mammoth—for occasional remains of this animal are found in the most recent caves of the Vézère, although a few leagues from there, at Excideuil, MM. Jules and Philippe Parrot discovered a paleolithic cave in which there was no trace of the extinct species, and even the reindeer was rare.

Thus the troglodytes of Périgord existed during the last two divisions of the Quaternary period, from the decadence of the mammoth to the disappearance of the reindeer. It is impossible to calculate the number of centuries they lived, but we can form some idea from the relation of their localities to the present level of the Vézère.

After the Moustier cave ceased to be inhabited it was frequently inundated by the Vézère, and gradually filled with alluvium. This stratum of earth, which is about 6½ feet in thickness, contains no osseous or siliceous remains. Below it lies the stratum which formed the habitation of man, in which he left traces of his industry and remains of his feasts. This proves that the opening of the cave was once beyond the reach of the waters, and consequently above the level of the river, while now it is 30 yards below low-water mark. The bottom of the valley has, therefore, been considerably elevated by deposition since the time of the troglodytes of Moustier.

On the other hand, the Madelaine locality, which is perhaps the most recent of the valley, is a little above the level of the highest present tide, and we may therefore conclude that the valley at that period was very much the same as it is now, the level having become only a little lower.

Thus this deposit of 30 yards, due to the action of the waters, was effected almost entirely under the eyes of our troglodytes, and since then, throughout the entire duration of the recent period, that is to say, for thousands of centuries, little change appears. Judge, then, what countless generations of humanity must have intervened between the time of the Moustier locality and that of the Madelaine.

It is evident that, in this immense lapse of time, the habits and manufactures of these people must have undergone great changes, which we find to have been the case in examining their different localities.

All the localities now known are found in a very circumscribed district, grouped on both sides of the river Vézère. From that of Moustier, the highest up the river, to the Eyzies, the lowest, the distance is only about 5 miles in a straight line, but almost double as far if the sinuosities of the valley are followed. Between these extreme stations lie, upon the right shore, those of the Madelaine, of Upper and Lower Laugerie, of the Gorge d'Enfer; on the left shore that of Cromagnon, very near the Eyzies. (See map.)

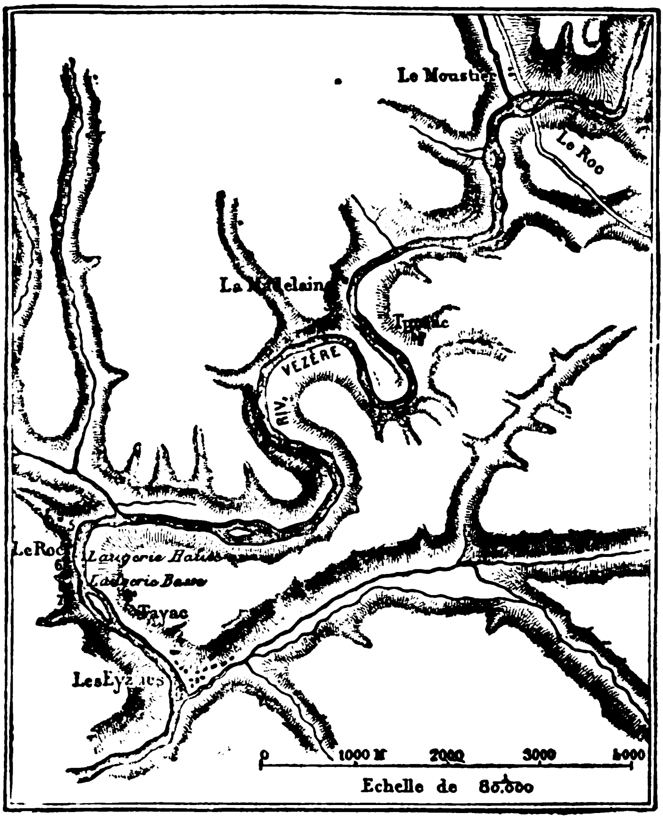


Figure 8.—Map of quaternary localities of the Vézère. 1. Cave of Moustier. 2. Hollow rock of Moustier. 3. Hollow rock of Madelaine. 4. Sepulcher of Cromagnon. 5. Hollow rock of Upper Laugerie. 6. Hollow rock of Lower Laugerie. 7. Cave of Gorge d'Enfer. 8. Cave of the Eyzies.

Some of these are genuine caves; others merely hollows in the rocks, largely open to the valley. At the Moustier there is both a cave and a hollow. The Gorge d'Enfer and the Eyzies are caves; the Madelaine, the two Laugerie, and Cromagnon are hollows, but these distinctions have no chronological importance. The most ancient troglodytes, as well as the more recent, used both the cave and the hollow; it is not from the kind of habitation they occupied, but from the nature of their remains, that we judge of their relative age.

The Moustier locality evidently preceded all the others; that of Cromagnon is less ancient, but still belongs, with the Moustier, to the intermediate age. The Upper Laugerie and Gorge d'Enfer are of the age of the reindeer; and, lastly, the Lower Laugerie, the Eyzies, and the Madelaine form a group which leads us to the end of the Quaternary period.

The troglodytes of the Moustier were completely uncivilized. They formed neither bone nor horn, but only stone implements. Tools of chipped flint abound in their various localities, but with the exception of a single arrow-head, which is carefully fashioned, these are of rude manufacture. No delicate objects; no small instruments; a few rare axes of the Saint Acheul type; a few thin pieces of stone, which may have been used for knives, and a large number of massive hatchets, with a single convex edge, to be held in the hand; such were the only implements of domestic use; all their other instruments were for warfare. A few arrow-heads prove that they were not ignorant of the use of the bow; but this was not their ordinary weapon. The true means of defense which characterized this period was the lance, or spear, already described. (See Figs. 3, 4, and 5.) This sturdy instrument, with ogival point, and both sides shaped, large enough to make severe wounds, yet small enough to penetrate the flesh easily, constituted a much more terrible weapon than the Saint Acheul ax. Fastened at the end of a spear it brought death to the largest mammal. Hitherto man, badly armed, could not compete with those powerful animals. He maintained with them merely a defensive warfare. But now he took the offensive. He ceased to fear them; their gigantic forms were no longer beyond his reach. With his long lance in his hand he assayed the conquest of the world.

At Moustier remains of the mammoth, of the great lion, and of the great hyena of the caves have been found; but the principal food of man at this period was first the horse, then the urus, and only third in importance the reindeer. The instruments of the chase were made for attacking game which would resist rather than take flight, and the arrow and other instruments for the killing of smaller quadrupeds or birds were probably unknown. Not a single bone of a bird or of a fish is found in the Moustier locality. These rude hunters cared only for violent combats, to which they devoted their entire energy and intelligence.

The men of Cromagnon, less ancient than those of Moustier, made noticeable progress; their tools were less massive, more numerous, more varied, and, above all, better made. The Moustier lance was superseded by a species of flint poignard. They wore ornaments of shells, and the large number of scraping-knives seems to indicate that they prepared skins for clothing. Their principal food was still the horse, but their larder was already varied. We find among the remains of their repasts, beside the reindeer, then commencing to be common, the bones and teeth of the urus, the boar, the stag, the goat, the wolf, the fox, the hare, and even of a bird of the crane species. Man hunted then the smaller animals, as well as large game, but he had not yet learned how to reach the fish.

Prominent among the animal remains we always find the mammoth and the great lion of the caves. There is also a great bear, probably the *Ursus spelæus.* The reindeer had not yet begun to multiply, and appears less frequently than the horse; so the period is still intermediate, while, in the localities we next notice, we enter definitely the age of the reindeer, and the remains of this animal are more abundant in them alone than in all the other periods taken together.

We observed at Cromagnon evident improvement in the manufacture of flint instruments; in the generations which followed further progress was made in this art, which attained its greatest perfection at Upper Laugerie. The most beautiful flint implements of the valley of the Vézère belong to this locality. All the industrial instruments and weapons found here are of flint. They are innumerable, and very varied in form and dimension. It is true, many are in no way remarkable; some are even very rude in construction, such as certain lance or spear heads, which resemble the Moustier. But side by side with these imperfect objects we find others of elegant form and elaborated contour, evidently the result of skillful workmanship.

These beautiful flint instruments of Upper Laugerie belong to the type called Solutré. Their form is sharply lanceolate; they have little thickness, and their sides, chipped into fine edges, are regular and symmetrical; their base is often fashioned so as to be easily inserted in a handle. They were evidently intended to be attached to the extremity of a long wooden handle. Their dimension varies greatly, but whether large, of medium size, or small, they are all very nearly of the same type. It is evident that the smallest are the heads of arrows; the medium size, of darts, thrown with the hand. The largest were lance-heads, but their want of breadth shows that the handle was not heavy, but quite light.

For combating the mammoth or great lion weapons such as these could not compare with the Moustier spear. But these dangerous animals had become rare. The brute creation no longer resisted man, but fled at his approach. Arms which were light and easily portable were necessary. If the reindeer avoided the lance he might be pierced by the dart; but, if too fleet for the dart, he could not escape the swift arrow. But the arrow and the dart failed of their end; they were too rudely constructed. The slightest irregularity or want of symmetry in form, a single point too heavy, caused them to deviate from their course This the men of Upper Laugerie understood, and they improved the working of flint in order to perfect their armory. They were guided by no artistic sensibility. Art was still a stranger to them; they had as yet only made acquaintance with utility. They gave a more elegant form to their arrow-head, only that it might fly with greater precision.

They did not take time to form their other implements with the same care.

These finely-formed arrow-heads, so common at Upper Laugerie, are not met with in the ulterior localities of the Vézère Valley. It would seem that the manufacture of flint instruments, after improving until the age of Upper Laugerie, then declined. It is astonishing that a people so skillful as the troglodytes of the age of the reindeer have proved themselves to be, should thus have allowed to perish their fundamental art. But several instruments found in their more recent localities show that they had not lost the secrets of this delicate workmanship, and if they ceased to form arrow-points like those of Upper Laugerie, it was because they no longer needed them.

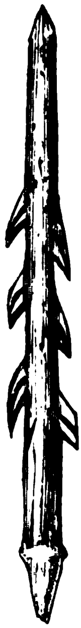
A great step had been taken. They had learned to make use of the antlers of the reindeer and the bones of animals. Out of these substances, more manageable than flint, not so hard undoubtedly, but still sufficiently strong, they manufactured implements for the chase of longer reach and greater precision; and having learned the value of horn and bone in the construction of such implements, they proceeded to form utensils of all kinds out of the same materials.

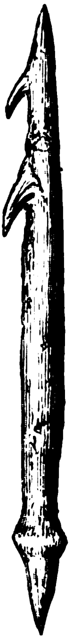
But the reign of flint was not over. On the contrary, there never had been a greater or more varied assortment of flint instruments; to those used as weapons, or utensils, had been added a number of small tools, used for working the horns of the reindeer.

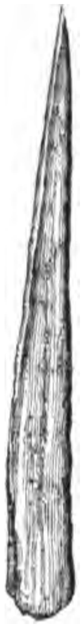
Here was an important evolution in industry. Hitherto the hand alone had been used in forming the manufactured substance, but now a secondary means was employed. Tools were made to use in constructing others. From the earliest times it is true that flint had been used as a means of manufacture. From the commencement of the Stone age it had been employed to cut wood, make piles, clubs, stems of lances, and arrows. Nor was the idea of substituting the hard parts of animals for stone any newer, for, in the ancient station of Cromagnon, several arrow-points of deer-horn, and even of ivory, have been found. What was peculiar to the period we are entering upon, was the creation of a kind of tool, which did not directly minister to the necessities of life, but was intended to facilitate and perfect the fabrication of the instruments in use. It was the commencement of that division of labor which later increased a hundred fold the power of man, and brought nature under his subjection.

The use of deer-horn was far advanced in the locality of Gorge D'Enfer. We find there a large assortment of lances, darts, arrows, bodkins, needles, &c., very well made, but without ornament, and the weapons for the chase are of very simple form, merely conical points, without barbs. (See Fig. 9.)

The invention of the barbs is worthy of attention. These recurrent points undoubtedly rendered the weapon more dangerous. The projectile remained fixed in the flesh, and the wounded animal could not get rid of it by brushing through the bushes. But this was probably not the principal intention of the barbs. Disposed in regular series on each side of the arrow (see Fig. 10) they sustained it in the air like wings, and added to the extent and precision of its flight this improvement indicates a certain acquaintance with experimental physics. The barbs generally have upon one of their faces one or several furrows, supposed to be intended to receive poison.







B. BECHER. DEL.

Fig. 10. Fig. 11. Fig. 9.

Figure 9.—Horn point without barbs, (Gorge d'Enfer.) Fig. 10.—Arrow with bilateral barbs. Fig. 11.—Harpoon with unilateral barbs.

The barb, and more or less artistic ornamentation, are the two distinguishing characteristics of the localities of the last period. These are three in number: the Eyzies, Lower Laugerie, and the Madelaine. They strongly resemble each other, and were probably almost contemporary. In some respects art is in a higher state of perfection at the Madelaine, but the difference is not sufficient to establish a chronological distinction. These three localities, remarkable for the number and variety of works of art and industry, have furnished the largest part of the means we now have of studying the life and habits of the troglodytes of the Vézère.

III.—The society of the troglodytes.

The caves of the troglodytes were situated at a short distance from the river, with no particular *orientation*, except that they were never open to the north. In them these people lived throughout the year, as we discover by the remains of their repasts. We find that the young of the deer formed their food at each stage of its development, and by the study of the teeth, the bones, and the growth of the horn, we can estimate their age, and, consequently, at what season of the year they were killed. We conclude, therefore, that the troglodytes had a fixed place of abode; in other words, that they were not nomads.

When they started on their fishing or hunting expeditions, they closed the mouths of their caves to prevent the incursion of carnivorous animals. A bone found at the Madelaine shows the marks of the teeth of a hyena, which, probably by accident, had gained admittance. The hyena was rare at this period, but wolves and foxes were numerous, and if the bones, scattered freely over the floors of the caves, were undisturbed by them, it was because they were carefully excluded.

By what means was the entrance to these habitations guarded? In other localities we find sepulchral caves closed by a slab of stone. This answered very well for the dead, but the living required a door more easily removed, and as no vestige remains in these caves of a defense of stone, we conclude that palisades were used for this purpose.

They lived by hunting and fishing. Did they add to their *régime* any vegetable nutriment? There is no proof of this. We find, it is true, in the three localities of the last period, a certain number of stones of granite, sandstone, or quartz, rounded and polished by friction, with a regular cup-shaped depression on one side, which resemble small mortars. It has been suggested that these were intended to receive the end of a piece of dry wood, which was then turned rapidly with the hands, in order to produce fire—a celebrated custom of the ancient Aryans, and still observed among savages; but these vessels are too shallow in proportion to their width for this purpose. They were evidently mortars, and certain rounded stones of the size of the cup seem to have been used as pestles. Hence has arisen the supposition that the troglodytes pounded or bruised grain to prepare it for food, but everything tends to prove that they knew nothing of agriculture, and these mortars were probably intended for the preparation of poisons or colors.

Their principal occupation and means of support was the chase. They hunted animals of every size, from the little bird to the huge mammoth. This old giant of Quaternary times still survived, although he had become very rare. For a long time it was supposed that he became extinct about the middle of the Quaternary period, and when several teeth of the animal, and various pieces of carved ivory were found in the more recent troglodytic localities of the Vézère, it was thought by many persons that these remains belonged to an anterior epoch; that long after the extinction of the mammoth, man collected and used the fossil ivory, as is done to-day by the people of Siberia. In that polar region the summer heat affects only a superficial stratum of the ground; the lower soil has been frozen for centuries, and has preserved the bodies of mammoths entire, so perfectly that their flesh is still good to eat, or rather very bad. One of my friends has tasted it, and found it tough as leather. Owing to these favorable circumstances the ivory of Siberia is in such a condition that it can be employed in the arts and in industry, but ordinary fossil ivory is only of value in the museum. The alternations of temperature and humidity to which it has been subjected have altered its texture—veined and softened it so that it is of no practical use whatever.

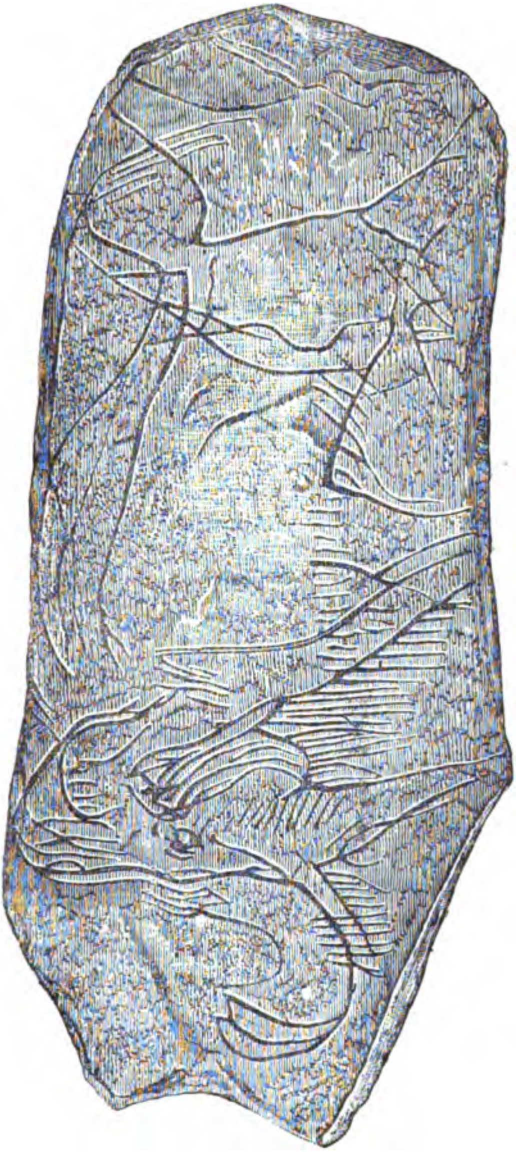


Fig. 12.

Now the climate of the Vézère, at the age of the reindeer, although still cold, had long ceased to be glacial, and if the men of the period had dug into the soil, which they did not, the fossil ivory they found would have been of no use. The mammoths, then, whose ivory they carved, must have been their contemporaries. We have besides a decisive proof of this. Here is a cast (see Fig. 12) of an ivory plate discovered in 1864 at the Madelaine by MM. Ed. Lartet, de Verneuil, and Falconer. Upon this plate is engraved a representation of the mammoth, with his large head, concave forehead, his curved tusks, his small eye, his trunk, his curled-up tail, and his long mane; in fact, exactly such a mammoth as perpetual frost has preserved, until our day, on the shore of the Lena.

The troglodytes of the age of the reindeer did not often encounter the mammoth. They more frequently hunted the boar, the horse, the ox. It was undoubtedly for combat with these large animals that they still retained some large lances armed with flint, differing little from those of Moustier. But their weapons were mostly light, and arrowheads of horn had replaced the flint points of the anterior periods.

The bow had become the principal weapon. The animal, as we have said, no longer defied man, but fled before him, and the combat was succeeded by the chase. There were two kinds of arrows. The small-pointed arrow, not barbed, for the smaller animals and birds, and the large arrow, with double rows of barbs, which was chiefly used in killing the reindeer. Light lances terminated with flattened points, darts with conical points, and long and sharp poignards, completed the equipment of the huntsman.

I was about to forget the rallying whistle. This was a bone of the reindeer, at one end pierced by an oblique hole, which did not pass entirely through the bone, but only to the medullary canal. By blowing upon this hole as upon a hollow key, sound can still be produced.

Fish furnished a means of support for our later troglodytes, unknown to their predecessors. Their various localities contain a great many bones, and, what is worthy of remark, they all belong to the fishes of the salmon species. Now, the salmon of the present day does not come up as high as the Vézère, nor even to that part of the Dordogne into which that river empties. A few leagues below the confluence of the two streams, not far from Lalinde, there exists in the bed of the Dordogne a bank of rocks, which in high water forms a rapid, and at low water a regular cascade, called the *Saut de la Gratusse.* This is the present limit of the salmon, and as, in the days of the troglodytes, they did not stop here, we must conclude that the level of the Dordogne since then has lowered, either by the wearing down of the bed of the river, which uncovered the rocks, or by loss of a portion of the waters.

These antique fishermen evidently did not use nets, for with nets all kinds of fish are taken. Their sole instrument was the harpoon, with which they could only catch the large fish, and among these they chose the one whose flesh they preferred. Had they boats for fishing? There is no evidence of it; besides the river was then sufficiently narrow to allow the use of the harpoon from its banks.

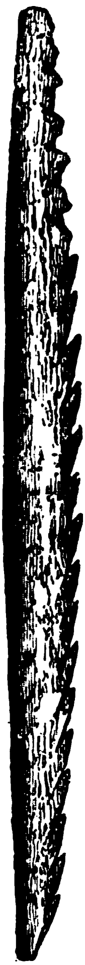


Fig. 13.

Harpoon of bone, of the inhabitants of Terra del Fuego.

The harpoon was a small dart of reindeer horn, very like the large barbed arrows, except that the barbs were only on one side; a slight protuberance at the base allowed a cord to be attached, which was held in the hand of the fisherman. (See Fig. 11.) It has been frequently, and is still, confounded with the arrow. It is clear that an arrow barbed only on one side would be very defective in flight, as it describes a long curve; its course is necessarily affected by the resistance of the air which sustains it; but in the short flight of the harpoon this inconvenience is much less, and besides the direction of the harpoon is downward, and it does not need to be sustained by the air. The instrument barbed only on one side is then not an arrow, and must be a harpoon. The use of its barbs was to catch and retain the fish after it was struck, but why were they all upon one side? To diminish the width of the dart so that it might penetrate more readily? I cannot say.*

After hunting and fishing the troglodytes resorted to the caves for their meals. They carried with them entire the carcasses of the reindeer, and the smaller animals they had killed, but the larger animals, such as the horse and the ox, were too heavy for transportation; they were cut up where they fell, and only the head and limbs were taken. This accounts for the fact that no bones of the body of the large mammifers are found among the residue of these feasts, while the skeletons of the reindeer and of the smaller animals are complete.

Throughout all these caves, wherever these broken bones are found, there is always a large amount of charcoal; and this association is so general, so uniform, that it is difficult to believe that the fires which were lighted, not only every day, but at every season of the year, were only for warmth. It is much more probable that they were used by the troglodytes for cooking their food.

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* One of my colleagues of the French Association, M. Lecoq, of Boisbeaudran, in a communication before the anthropological section, makes some very interesting remarks upon the mode of action of the unilateral barbs of the harpoon. While passing through the air these barbs do not cause the harpoon to deviate perceptibly, but as soon as it enters the water the unequal resistance it encounters must necessarily change its direction. It would seem, then, that the fisherman who aimed straight for the fish would miss it. Now, it is well known that a straight stick appears to be broken when plunged obliquely in water; in like manner, in consequence of the refraction of the luminous rays, the image of the fish is displaced, and if direct aim was taken at this image it would also be missed. Here are, then, two causes of error. Now, it is evident that if they can be brought to act in opposite directions they will counteract each other, and M. Lecoq shows that when the barbed side is turned up the harpoon will reach its destination. This arrangement of the harpoon was then intended to rectify its course, which indicates great sagacity of observation in our troglodytes.

The inhabitants of *Terre-de-Feu* still use a harpoon barbed on one side only. (See Fig. 13.)

We do not know how they produced the fire; whether by striking flint, or heating wood by friction. Nor do we know anything about their arrangements for cooking. They had no pottery, and could not boil their meat; neither did they roast it, for only occasionally calcined bones are found, and these are calcined evidently by accident. It is possible that they used wooden vessels, in which the water was brought to the boiling-point by the immersion of red-hot pebbles, but it seems to me much more probable that the food was cooked under the ashes, as is still the custom among savage people.

They were very fond of the brain of animals, and of the marrow of the long bones, for the heads and the marrow-bones (to the exclusion of all others) are uniformly broken. Marrow is considered a great delicacy among all savages. They break the bone in a peculiar manner, and the head of the tribe is honored with the first suck. Our troglodytes used wedge-shaped pieces of flint as a kind of hatchet for breaking the bones. They also had an instrument of horn, which was probably employed in extracting the marrow. (See Fig. 14.) Archæologists disagree in regard to this instrument. Some have supposed it to be a dart, because one of its extremities, if not pointed, is conical in shape, and that the cavity formed in the other was intended to admit the handle; but, if so, the latter extremity would not have been sharpened to an oblique point before the cavity was made. On the contrary, the part used for the handle, where strength was required, would have been heavier, not smaller and weaker. Besides, the elegant ornamentation of the exterior surface indicates that it was an object of luxury. The time required for such work was not wasted in forming a weapon which might be lost in the first thicket encountered. I therefore think, with Edward Lartet and Christy, that this instrument was for extracting marrow, and was only used by persons of distinction.

The troglodytes, when their repasts were ended, left the bones scattered upon the ground. In a warm climate these would have exhaled frightful odors, but we must remember that the temperature was much lower then than now. Moreover, we must admit that cleanliness was not the dominant virtue of the men of this period, but their want of neatness serves us well, for, in consequence, the floors of their caves show us exactly what they had to eat. The flesh of the reindeer was their principal food, but they also lived upon the horse, the urus, several species of ox, the chamois, the goat, and even of the carnivorous animals. Thus far they but followed the example of their predecessors; but they had, in addition, the products of the fisheries, while the improvement of the bow enriched their larder with a great variety of birds, whose bones are found among the remains of the repasts.

Among all these osseous fragments there is not a single human bone. Our good troglodytes were not anthropophagi. They were unacquainted with the savage delight of eating a vanquished enemy. I state this with satisfaction, although I am not of the number of those who attach great importance to cannibalism. In the eyes of a philosopher the crime consists not in eating the man, but in killing him. In the latter respect we are perhaps more barbarous than they, for our boasted civilization, which ought to put an end to war, has only rendered it more murderous. I do not suppose the troglodytes always lived in peace; they were obliged sometimes to fight in order to defend or increase their hunting-grounds, but their weapons are those of men of the chase—hunters, rather than warriors.

Fig. 14. Fig. 18. Fig. 17. Fig. 15. Fig. 16.

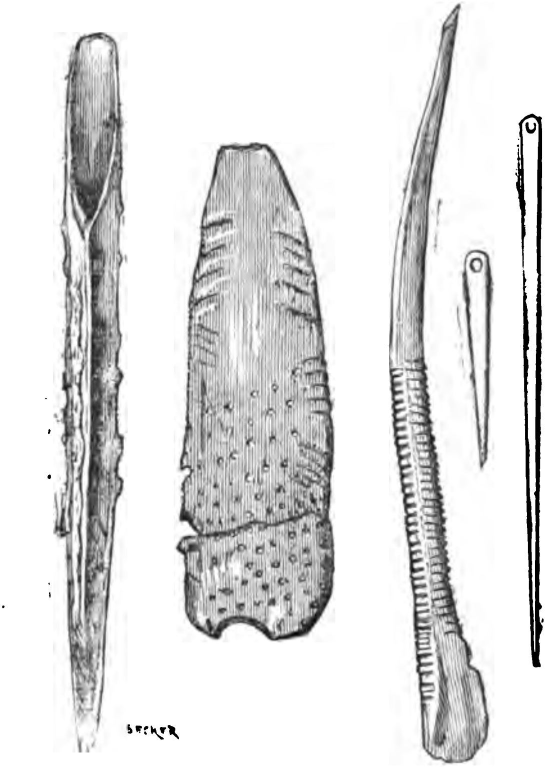


Fig. 14. Spoon for marrow. Figs. 15 and 16. Needles. Fig. 17. A hunting scorer and marker. Fig. 18. Record.

When we review their panoply we find their most formidable weapons, those which could be used in a hand-to-hand conflict, are few in number, so we must conclude that they were pacific in their habits.

It has been supposed that they wore no clothing, because the figures of them drawn by their artists are entirely naked. But this is no proof; the Greeks always represented their gods and heroes in a state of nudity.

We found in the caves all the instruments needful for sewing. They had needles of bone and horn; some with only a point like our shoemaker's awl; others with an eye for carrying thread. (See Figs. 15 and 16.) Some are very fine; we have seen a needle-case made of the bone of a bird, which contained several needles. Lartet and Christy have discovered the mode of manufacture. They found a metacarpus of a horse, in which, made with a fine saw, were incisions, longitudinal and parallel, isolating narrow and regular pieces of bone. The work was unfinished, but it is evident that these isolated splinters of bone were to be formed into needles.

The nature of the thread employed varied greatly. Did they use vegetable fiber and narrow slips of leather? It is possible, and even probable. It is certain that our troglodytes made thread, or at least cord, out of tendons. Several savage tribes at this day use fine tendinous fibers for sewing. The large posterior ligament of the herbivora might have furnished thread and cord of great strength. I have known this part of the ox to be used in more recent times by parents, in the moral improvement of their children. Whether the sinews of the reindeer were used for sewing I do not know, but the long tendons of the limbs were detached with great care, by means of a peculiar stroke which produced a slight but regular abrasion of the bone. This abrasion, always the same, is found on different bones, but always at the point of insertion of a tendon, and was evidently the result of an operation methodically performed, probably before the animals were handed over to the cooking department, and which had for its object the preparation of thread for sewing.

The art of sewing implies the existence of clothing, not merely that primitive vesture which consists of a single skin thrown over the shoulders, but a much more complete raiment, formed, perhaps, of several skins. The abundance of needles, and of scrapers used in the preparation of skins, shows that the use of clothing was general.

They also wore ornaments, which, perhaps, served as marks of distinction, such as bracelets and necklaces formed of shells, perforated and strung together. These are found in almost all the localities, and in great numbers in the ancient burial-place of Cromagnon. Some plates of ivory, prepared with great care and pierced with two holes, seem to have served as fastenings for these necklaces.

These were not the only manifestations of that spirit of vanity which leads man to adorn himself. Almost all savages make use of paint, and the barbarous practice of tattooing, in order to embellish their persons, and we have no right to look down upon them, for in the most civilized countries the tattoo is still in favor, especially among sailors, and the fine lady of society has not, it is said, entirely forgotten the use of pigments. It is therefore not surprising that we find among the troglodytes similar customs. Their caves contain numerous fragments of a species of redstone, called *sanguine*. The stripes observed upon these show that they have been scraped. A red color was thus formed, which was constantly used in personal adornments. It is likely that tattooing also was practiced, since among the figures engraved upon various objects of reindeer horn, there are several representing the hand and fore-arm of a man, and upon the lower part of the fore-arm are designs in such regular patterns they can hardly be anything else than tattooing.

I have already said our troglodytes were not nomadic; individuals may have undertaken long journeys, but the tribe seldom or never wintered far from the cave. They must have obtained, by exchange or commerce, certain articles foreign to the locality, such as the perforated shells, of which their necklaces and bracelets were made. These were mostly of the species *Littorina littorea*, and came from the shores of the Atlantic, where they are abundant. They were recent shells, that is, not fossils, which is proved by the tints they retain to this day. There are others also pierced with a hole for suspension, which belong to five extinct species of the Miocene age. They are entirely discolored; and their molecular condition and worn appearance prove that they had been for a long time in the fossil state before they were unearthed to assist in adornment. Now the places where these fossils were found were not in the neighborhood of the Vézère; the nearest were those of Touraine, and thence, in all probability, our troglodytes imported this addition to their toilet. We also find at these localities, and especially at Upper Laugerie, small objects of rock-crystal, which substance must have come from the Pyrenees, the Alps, or the mountains of Auvergne. The foreign relations of the troglodytes were therefore far extended.

Had they religious belief? We found in their dwelling-places no objects which could serve for worship; but they wore a talisman, or amulet, which consisted of a canine or incisor tooth of the wolf, the reindeer, the ox, or the horse; a hole was carefully perforated in one end of the tooth to receive the suspending cord. Similar talismans are worn at the present day to assist the fortunes of the chase, and M. de Mortillet has observed in Italy an analogous custom. To counteract the influence of evil spirits, the tooth of a hog, mounted in silver, is fastened to the swaddling-clothes of the new-born child; and later, when the teeth commence to appear, it is suspended from the neck of the infant, and serves as a coral or rattle.

The perforated teeth of the troglodytes were certainly not rattles; they were, perhaps, protective amulets, but more probably talismans for hunting. In either case, they were objects of superstitious veneration. May it not then be said that these people had a religion? I am no theologian; I cannot say. It is difficult to know where superstition ends and religion begins.

At the same period of time in other places certain funeral rites were observed. The dead were deposited in a cave, the narrow opening of which was closed with a stone slab. In front of the cave was a small esplanade upon which the afflicted relatives comforted themselves with a feast. This mode of consolation has been continued from age to age, even down to the present time.

At present only one burial-place of the troglodytes of the Vézère is known—that of Cromagnon. It is a hollow rock, not a cave. Near the bodies were placed some flint instruments and ornaments of shells, but there is no trace of a closing stone.

The government of the troglodytes was hierarchically organized. There were dignitaries of several degrees of importance. The proofs of such organization are found only in the localities of the latest period: the Eyzies, Lower Laugerie, and the Madelaine. They consist of certain large pieces of the horn of the reindeer, carefully formed, and generally called rulers' staves or batons. They are very numerous, and of a uniform type. Their entire surface is richly ornamented with various designs, representing figures of animals, or hunting scenes. The care taken to make them as thin as possible, in proportion to their width, shows that lightness, and not strength, was desired. Most of them, not all, have, in one of their extremities, round holes, varying in number from one to four. (See Figs. 19 and 20.) The destination of these

Fig. 21. Fig. 19. Fig. 20.

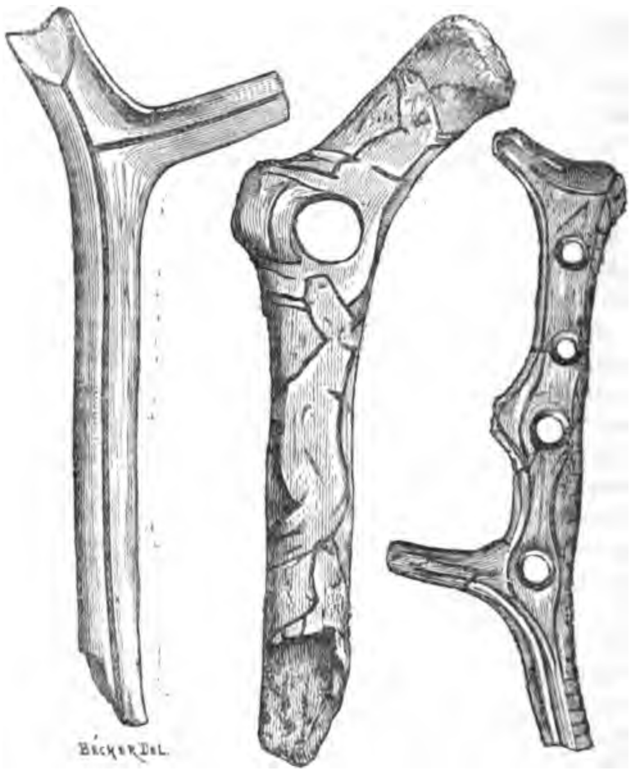


Fig. 19.—Ruler's stave or baton, with one hole, reduced to one-third. Fig. 20.—The same, with four holes, reduced to one-third. Fig. 21.—The pogamagan of the Esquimaux, reduced to one-fourth.

remarkable instruments has been, and still is, a subject of discussion. They have been considered weapons, and it must be confessed they resemble in form the *pogamagan* employed by the Esquimaux of Mackenzie's River as a tomahawk, one end of which, formed into a blunt chisel, serves to break the ice. The pogamagan, however, are longer, larger, and heavier, and instead of being flattened their cylindrical form has been preserved, so that, resistance being equal in every direction, they admit of violent blows. They also are not pierced by the large holes which rendered the batons of the troglodytes too fragile for any mechanical use. These batons may then be considered as the insignia of office. They recall the scepter of the ancients, which was carried not only by kings, but by chiefs of lower rank. At the present day the dignity of a marshal is represented by a baton, a similar symbol of office.

The batons of the troglodytes are too numerous to be marks of royalty. They were simply signs of hierarchal distinction, the holes, like the gold and silver lace of our officers, indicating the rank of the wearer; those with four holes represented the highest office; those without any, the lowest.

The unity of design in the ornamentation, which generally includes the holes, shows that the baton was made after the individual for whom it was intended was invested with his office. But in some cases the holes were evidently added afterward, as they cut into and mutilate the drawings. For instance, on one baton a horse is represented; and, later, a hole was pierced, which divided the horse into two portions, (see Fig. 19,) the possessor having been so fortunate as to receive a promotion.

This division into ranks, or grades, a sure sign that the community was large, may have arisen out of the necessities of war; but it is much more probable that they originated in the organization of hunting expeditions, for the chase was the principal element of public prosperity, and it was of the utmost importance that it should be properly regulated, since upon it depended the sustenance of the whole people. The temperature was then much lower than it is now, and the flesh of the game could be preserved for a long time, especially during the winter months, so that there was constantly a greater or less amount of food stored in the cave, and the intervention of a domestic economy was necessary to avoid either waste or unjust division of these provisions. Certain rods of horn, with a great number of notches upon them, arranged in regular series, seem to have served as account books. These objects, known as *hunting registers*, (see Fig. 17,) resemble the recording sticks used at the present day by the bakers of small villages, and in the country, to keep the accounts of those, alas too numerous, who can no more read than our troglodytes. A wide, thin plate of bone, or ivory, with two rows of notches on the sides, and its two faces covered with series of points arranged transversely, seems also to have been a register of accounts. (See Fig. 18.)

Thanks to the organization and administration whose indications we have just noticed, the troglodytes, though a large community, lived at ease. Food was so abundant that they could select the better parts, and reject those inferior in quality. Thus they disdained the feet of animals, which contain, between the bones and tendons, a considerable amount of alimentary matter, and we find in their caves entire feet of the deer, with every bone in place, as perfect as those of the skeletons of our museums. They were evidently cast aside as undesirable for food, a fact which shows that the sources of subsistence more than supplied actual need. The destruction of the dangerous animals had insured safety, and the perfection of the chase secured abundance of food. The more urgent necessities of life no longer required an entire consecration of the activity, intelligence, and time of the tribe. Leisure hours were possible, and leisure, combined with intelligence, engenders the arts.

IV.—THE ARTS OF THE TROGLODYTES.

To Egypt no longer belongs the distinction of having originated the arts. We learned a few years ago, to our great astonishment, that the men of the age of the reindeer practiced drawing, carving, and even sculpture. At first their efforts received only our admiration; but now, the excitement of discovery over, we must confess there were some very bad artists among them. Still, although a large number of the drawings are very crude, resembling the rude sketches made by idle children with charcoal upon our walls, there are some truly remarkable, indicating not only a skillful hand, but an eye accustomed to the observation of nature.

Drawing, with these people, undoubtedly preceded sculpture. Figures in relief are much more rare and less perfect than those made by lines. The latter are found quite frequently at the Eyzies, and at Lower Laugerie, but are particularly abundant at the Madelaine, where they are also much more correct.

All the drawings are made with indented lines, that is, etched, and for the most part ornament various objects of reindeer horn, such as the commanders' batons, or the handles of poignards. There are some, however, made upon certain plates of ivory or horn, which could have been intended for no other purpose than to receive and display the work of the artist. (See Fig. 12 and Fig. 22.)

Almost all the drawings are of natural objects, although there are some merely ornamental lines, forming zigzags and festoons of more or less elegance; and, with the exception of three rose-like leaves engraved upon the handle of deer's horn, which seem intended to represent a polypetal flower, they are principally of animals. The reindeer most frequently appears, then the horse; the ox and the urus more seldom. These animals are readily recognizable. Their characteristics are reproduced with great accuracy, and often with elegance; frequently they are isolated figures, covering without order, and in great numbers, the entire surface of an instrument, but sometimes they are formed into groups, and are seen in combat, or flying before man.

Of all these drawings the most important, and also the most rare, since, at present there is but one specimen, is a representation of the mammoth, to which I have already alluded. It was found at the Madelaine in 1864. The execution of the head is remarkably correct. (See Fig. 12.) Since then the Marquis de Vibraye has discovered at Lower Laugerie a fragment of a commander's baton, with the head of a mammoth sculptured upon it. These are the only representations of the animal transmitted to us by the artists of the Vézère, but they are sufficient to prove that it was not yet extinct.

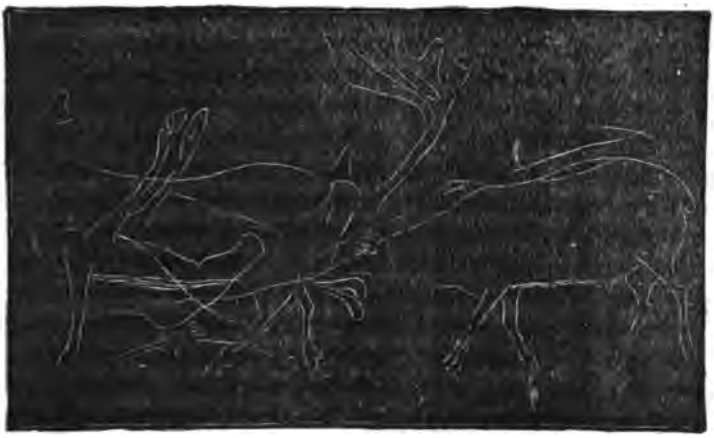


Fig. 22.—Combat of reindeers.

Representations of fish are quite common, and, with a single exception, that of an eel or lamprey, (if it is not a serpent,) they generally resemble the salmon in form. M. Elie Massénat has discovered at Lower Laugerie, upon a fragment of the scapula of an ox, a rude drawing of a fishing scene. It represents a man in the act of harpooning an aquatic animal. The latter, although it has the form of a fish, is so much larger than the man that it has been supposed to be one of the cetacea, probably a whale, and that the artist, in consequence, must have found his way to the Gulf of Gascogne. I am not disposed to admit this interpretation. It is hardly possible that the men of that time were sufficiently expert navigators to venture upon the ocean to harpoon the whale. It is said the tail and back suggest the form of a cetaceous animal; but may it not rather be a porpoise than a whale? Porpoises sometimes sport in the Gironde, and I saw once, in my childhood, one of these animals carried by a flood even into the Dordogne, where it was stranded between Libourne and Castillon. It was killed by fishermen with boat-hooks, and exhibited from village to village. If, as is probable, the tide rose higher in those days than now, and particularly if the Dordogne was wider and deeper, it is conceivable that a porpoise might ascend the river high enough to come within reach of the harpoons of our troglodytes, and so unusual an event would naturally inspire the enthusiasm of an artist—in this case very unskillful.

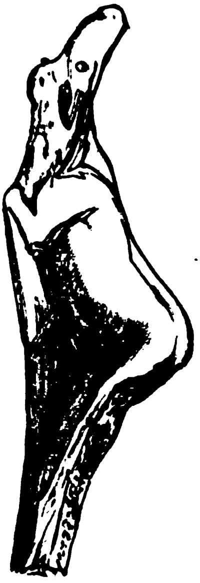
But I am tempted to believe that this pretended cetacean is only a badly drawn fish. The relative size of the man proves nothing, for the artist throughout the entire sketch has manifested entire contempt for proportion. This too diminutive man has a gigantic arm, and the harpoon he throws is proportioned to the size of the fish. We are reminded of certain jocose drawings of the present day, in which puny bodies are supplied with enormous heads. The great interest of this particular work of art consists in the unanswerable proof it gives that the troglodytes used the harpoon in fishing. I have already shown by indirect evidence that the darts, barbed only on one side, could only be used as harpoons, and this drawing fully confirms that conclusion.

The troglodytes, sometimes so skillful in the representation of animals, drew the human form very badly. They very seldom attempted it, and only a single study of a head has been found. It is in profile, very small, and very grotesque. Two other drawings, very similar to each other, represent a fore-arm, terminated by a hand with four fingers, the thumb hidden from view. Add to these the fisherman with the harpoon, and two hunting scenes, in which a man entirely naked, and armed with a dart, or baton, is very rudely drawn, among figures of animals very skillfully executed, and you have a complete list of all the representations of man to be found in the gallery of the troglodytes.

I have already said that the specimens of sculpture are much more rare than the drawings. We only know of about half a dozen, and they all came from Lower Laugerie. One of them, belonging to the Marquis of Vibraye, represents a woman; the others the following animals: a reindeer, (see Fig. 23,) the head of a reindeer, the head of a mammoth already mentioned, and the head of an animal not yet identified; lastly, a specimen discovered by M. Elie Massénat, called the twin oxen, representing two animals which may be either oxen or uri.

These sculptures are sometimes unfinished, and always badly executed. It is true they ornament the handles of poignards, or commanders' batons, and in order to accommodate the animal forms employed to this purpose, the artist was obliged to choose unnatural and ungraceful positions; but, in spite of these extenuating circumstances, it must be confessed that the troglodytes were very poor sculptors.

Fig. 23.



Carved head of a poignard, representing an elongated reindeer.

On the contrary, in the art of drawing they manifested surprising skill. From I know not what reason they paid little attention to the human form, and failed in its representation, but the characteristics of animals were reproduced with such faithfulness, elegance, and spirit, as to denote true artistic feeling.

V.—THE RACE.

In concluding the study of this interesting people we will now determine the race to which they belong. The human bones thus far collected are, unfortunately, not sufficiently numerous to satisfy entirely our curiosity. Still, they suffice to prove that their race was very different from those which succeeded it, and that the learned anthropologist Retzius and his disciples were mistaken in supposing that all the populations of Southern Europe, before the comparatively recent period of the Indo-European migrations, belonged to the type of the *short heads*, or *brachycéphales*.

M. Elie Massénat discovered a few months ago, at Lower Laugerie, the skeleton of a man who appeared to have been killed by an accidental fall of earth. But the anatomical description of this valuable specimen has not yet been published, which I especially regret, since it is the sole representative of the troglodytes of the latest period. The skulls and bones in the annexed drawings belong to a very much more ancient date. They came from the ancient sepulcher of Cromagnon, of which M. Louis Lartet, worthy son of an illustrious father, has determined, with great accuracy, the geological, paleontological, and archæological characteristics. This burial-place contained the remains of at least five individuals; but only three skulls, two masculine, one feminine, were sufficiently preserved for examination. One of the men was apparently very old; the other was an adult, as was also the woman. Near them was a young child.

They were superior in stature to ourselves. The length of the femur of the old man indicates a height of five feet nine inches, while the size of the bones, the extent and roughness of the surfaces of muscular insertion, and the extraordinary development of the maxillary bone, in which are inserted the masticatory muscles, manifest a strong constitution.

The tibias, instead of being triangular and prismatic like ours, are flattened like those of a gorilla. (See Fig. 24.) The upper part of the cubitus is very large and curved, and has a very small sigmoidal cavity, which characteristics recall the cubitus of the gorilla. But the confomation of the femur differs radically from that of the apes. With the anthropomorphous apes the body of the femur is flattened, is much wider than it is thick, and has not upon its posterior surfaces the longitudinal crease which in man is called the *sharp line*. In existing races the thickness of the body of the femur is, in general, greater than its width, but the difference is slight. In the specimens of Cromagnon the femur is much thicker than wide. The sharp line, enormously developed, is no longer a simple ridge, but a thick and prominent osseus column, which greatly increases the strength of the bone and the extent of the muscular insertions. In this respect the people of Cromagnon differed much more from the simian type than the present races.

The skeletons of these robust troglodytes bear traces of the violence of their manners; in the lower extremity of one of the femurs of the old man is a hollow similar to that sometimes produced in our day by a spent ball. It is evidently the result of an old wound received, perhaps, in the chase; perhaps in war; but a human hand, armed with a flint instrument, must have produced a long, deep aperture which appears

Fig. 26.

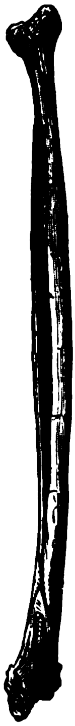


Fig. 24.

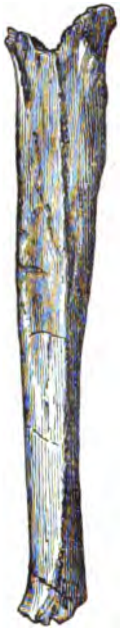


Fig. 25.

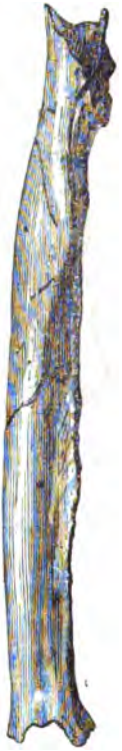
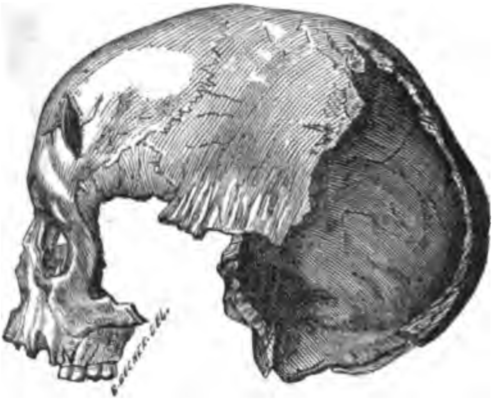


Fig. 24.—Flattened tibia of the old man of Cromagnon. Fig. 25.—Femur of the same in profile. Fig. 26.—Fibula of the same.

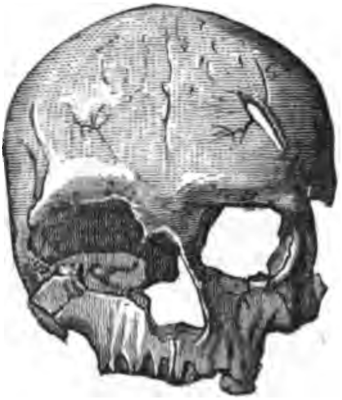
in the skull of the woman; the width of the opening shows that the brain must have been injured, but still the victim was not killed instantly by the blow. The vascularization of the bone and the internal surface of the skull show that she survived about fifteen days. (See Figs. 27 and 28.) This shameful murder of a woman is not to the credit of the people of Cromagnon. The study of the industries of these people has already shown us that their social condition was not above that of a savage tribe, and an examination of their skulls confirms this opinion. With them the sutures of the anterior cranial region are very simple, while those of the posterior region are quite complicated. Besides, the former have a decided tendency to close long before the latter, two characteristics always observed in races or individuals leading an entirely material life. The troglodytes of Cromagnon were then savages, but savages of intelligence, and capable of improvement. We find among them certain signs of a powerful cerebral organization. The skulls are large in diameter, curve, and capacity, and surpass the mean of those of existing races. They are very elongated in form, such as are called dolichocéphales, (which means long headed,) but this shape of the head is not due, as with the Australian negroes, to narrowness of the skull; on the contrary, the transversal dimensions are well developed; it is the increase of the antero-posterior diameter which gives the elongated form; the alveolar arch of the old man is oblique, but the upper part of the face is vertical, and the facial angle very obtuse. The forehead is wide, not receding, and describes a beautiful curve. The amplitude of the frontal compartment denotes a great development of the anterior cerebral lobes, which are the seat of the most noble faculties of the mind.

Fig. 27.



Skull of the woman of Cromagnon in profile; the aperture in the frontal bone is apparent.

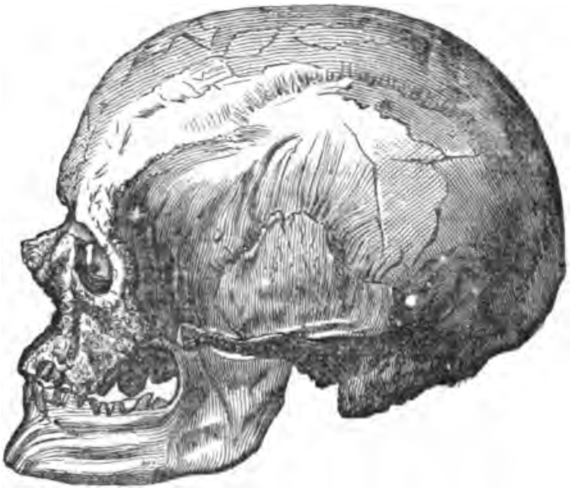
Fig. 28.



Skull of the woman of Cromagnon; front view.

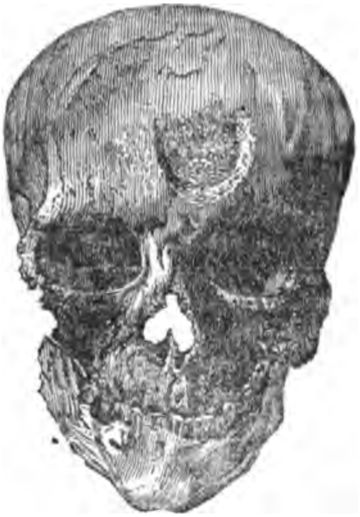
If the troglodytes of Cromagnon were in a savage state it was because the surrounding conditions were unfavorable to their development. The conformation of their brains shows that they were capable of culture, and, under favorable auspices, would make great and rapid advances in civilization. These rude hunters of the mammoth, the lion, and the bear are the worthy ancestors of the artists of the Madelaine.

Fig. 29.



Skull of the old man of Cromagnon; profile view.

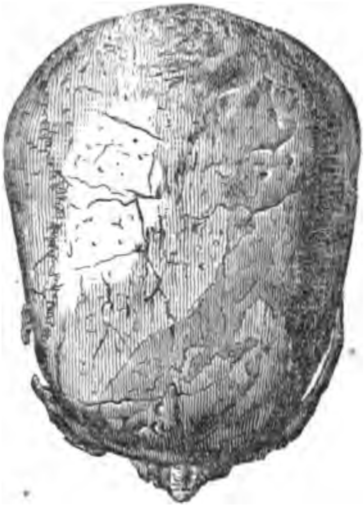
Fig. 30.



Skull of the old man of Cromagnon; front view.

I have now given you the principal facts in the history of the troglodytes of the Vézère. For want of time I have been obliged to omit and curtail much that would have been interesting to have dwelt upon, but hope that you have been enabled to follow from Moustier to Cromagnon, from Cromagnon to Upper Laugerie and George d'Enfer, and then to the three localities of the Eyzies, Lower Laugerie, and the Madelaine, the progressive evolution of an intelligent race who advanced gradually from the most savage state to the very threshold of civilization; for the troglodytes of the last period, with a regularly organized society, and possessing industry and the arts—the two great levers of progress—were, so to say, within one step of a truly civilized condition.

Fig. 31.



Skull of the old man of Cromagnon; vertical view.

This interesting people suddenly disappeared, leaving no trace in the traditions of men, not gradually, after a period of decadence, but rapidly, without transition, perhaps suddenly, and with them the light of the arts is extinguished. Then follows a period of darkness, a sort of middle age, of unknown duration. The chain of time is broken, and, when we would resume it again, we find in the place of the hunters of the reindeer a new society, a new industry, a new race, a people who are acquainted with agriculture, who domesticate animals, raise megalithic monuments, and have the ax of polished flint. It is the dawn of a new day, but the knowledge of the arts has been lost. Sculpture and design have entirely disappeared, and it is not until the latest days of polished stone that we discover, and then only here and there upon an occasional monument, some attempts at ornamentation, which have absolutely nothing in common with the remarkable artistic productions of the troglodytes.

This sudden and complete extinction of the troglodytes suggests the occurence of a cataclysm, but such a supposition is contradicted by geology, and, in order to explain this phenomenon, it is not necessary to introduce any other influence than that of man. Our hunters of the reindeer, with their peaceable mode of life and their light weapons, were not prepared for combat, and not in a condition to resist attack, so that their budding civilization yielded immediately when their valleys were invaded by tribes better equipped for war; perhaps already in possession of the polished ax. Then, as now, might was right.

APPENDIX.

EXCURSION TO THE EYZIES.

At 5 o'clock a special train carried seventy-two excursionists; the sun arose in splendor and announced a beautiful day. The road as far as Periguex presented little to attract attention, and animated conversation beguiled the time until at 6 o'clock we entered the celebrated valley of the Vézère, and stopped at the station of the Eyzies.

After partaking of an excellent repast prepared for us, at 11 o'clock we climbed the steep sides of the eminence which overlooks the present village, on the banks of the Beune, and, surrounding M. Louis Lartet, were so fortunate as to hear a detailed account of the discoveries which have rendered so illustrious the cave of the Eyzies, where his father, our regretted master, with the aid of Christy, commenced his series of distinguished explorations.

The cave still contains numerous osseous fragments, in which are mingled pieces of bone, flint implements, rounded or angular pebbles and schistose plates of rock, for the most part foreign to the valley. Many a museum has been enriched by similar fragments from the Eyzies by MM. Ed. Lartet and Christy, and we were each allowed to collect some specimens. In this cave were found the first drawings of the age of the reindeer. (August, 1863.)

Near the entrance of the cave, upon the lateral and exterior prolongation of the platform are traces of artificial constructions, of a relatively very recent period. A stable was partly suspended in the air, and covered, doubtless, with a pent-house roof supported in holes in the rock which still exist.

We then proceeded to Cromagnon, a place very celebrated in the annals of science. In 1868 the construction of the railroad necessitated the removal of an enormous talus at the base of the rocks on the left shore of the Vézère, and at the bottom of a cave so shallow it might rather be called a hollow, some human bones were discovered. M. Louis Lartet was immediately sent to the place by the minister of public instruction, and found that there were four superposed strata blackened by fire.

In all these strata were the same industrial implements, flint chiefly shaped into scrapers, instruments of bone, bodkins, arrows, &c., and also the same animals—the great bear, *Felis spelæa*, the wolf, *Canis vulpes*, a spermophile, two *Lepus*, the *Elephas primigenius*, the *sus*, the horse very abundant, the reindeer, the urus, some teeth of the common deer, and lastly a species of goose. Without a doubt the vestiges of successive habitation in the hollow of Cromagnon are traces of the same race of hunters. When the accumulation of culinary *débris* had considerably reduced the height of the little cave it became the final abode of a few of these ancient people. Five skeletons, a woman, a child, an old man, and two young men were found in it, and, with them, nearly three hundred marine shells, especially the *Littorina littorea*, some amulets of ivory-pierced teeth, instruments of reindeer horn, &c.

From the absence of barbed arrows and of engraving on stone, and from the predominance of the horse over the reindeer, Cromagnon dates before the last period of the caves, and is very nearly contemporary with that of Upper Laugerie, which was visited immediately afterward by the association. Each member had been supplied by M. Emile Cartailhac with a map of the valley of the Vézère, on the side of which were represented the excavations of Cromagnon and Lower Laugerie.

In passing to Tayac the association stopped for a few moments to examine an interesting Roman church; a short distance further on they crossed the Vézère in a ferry-boat, and were charmed with the picturesque aspect of the valley. The right branch of the river is not wide, and the steep declivities which rise almost vertically are less than 50 meters from the river. Above the hamlet of Upper Laugerie we observed a talus with a line of enormous blocks of stone upon it, and were told that it was a cornice of rock which had fallen during the last century, destroying human habitations, sheep, and cows in its descent. The present occupants of the soil, with no fear of a similar accident, have rebuilt their miserable cabins upon some of the fallen rocks. It is here that MM. de Vibraye and Franchet collected, sometimes below the level of the waters of the Vézère, large quantities of those flint instruments with oval ends and both sides shaped, which have become characteristic of an intermediate period between the age of the locality of the Moustier which succeeded that of Saint Acheul, and the age of Eyzies, of the Madelaine, &c.

Above this important stratum lie the deposits of the last period of the time of the reindeer, which witnessed the birth of industry and the arts, of drawing and of sculpture. These commence at Upper Laugerie, and continue for several hundred yards toward Lower Laugerie, where they form a talus of 12 meters in thickness. Protected from the damp by the overhanging rocks, the bones are admirably preserved, and the excavations made have been attended with astonishing results. MM. Ed. Lartet and Christy, and the Marquis of Vibraye commenced the work which was continued for six years by M. Elie Massenat, (de Brives.)

Numerous relics of every period have been collected at the surface of the talus, but especially of the age of bronze and of polished stone.

The superficial strata have been frequently searched for specimens, as they still continue to be by the present inhabitants. These poor people even dig up the floors of their dwellings for this purpose, and we were quite astonished to find deep holes under their beds and tables and bureaus, excavated for the extraction of these vestiges of ancient life.

We have especially noticed the avalanche of rocks of the Upper Laugerie, but similar occurrences have taken place all along the valley. Rocks have constantly fallen. The savages of the age of the reindeer were established on the banks of the Vézère when the valley was in its present condition. Undismayed by the avalanches of stone which, at intervals, destroyed their homes, they fearlessly re-assumed possession of the soil and rekindled their extinguished fires in the space between the fallen rocks.

It is between the rocks, therefore, that the excavations have been made, but these irregular subterranean passages are difficult and dangerous to explore. The day before our visit heavy rain had fallen, the Vézère had risen 3 meters, and the modern troglodyte who was in M. Massénat's employ had heard ominous cracking sounds. The rocks around which the opening had been made had settled down, and at any moment might fall. Prudence deterred us, the excursionists, from venturing into the deep passages, through which it would have been necessary to crawl on hands and knees; and, by the light of a candle, we looked into an opening black as night, in which we could see broken bones and flint instruments without number. M. Massénat then conducted us to the place where, last March, in company with MM. Lalande and Cartailhac, he had exhumed an entire human skeleton, all the bones of which have been preserved and cast.

The members of the association were convinced that these valuable remains were contemporary with the great extension of the reindeer in the country, but one of their number was doubtful as to the cause of their presence position. He supposed that the place in which they rested must have been a sepulcher. MM. Massénat, Lalande, and Cartailhac, who had carefully observed every circumstance of the discovery, thought that the man had been killed by the descent of an avalanche, and Professor Broca and others adopted the latter opinion.

M. Massénat spoke of the human bones he had frequently found in the kitchen remains, which he regarded as a proof of cannibalism, or at least that the men of the age of the reindeer paid little respect to their dead, a fact which increased his doubts as to the existence of sepulchers at this time, although later they were employed, beyond a doubt.

But time was passing, and, leaving Lower Laugerie, where each member of the association had made ample collections of flint instruments, fossil bones, reindeer-horn, &c., we descended to the Gorge D'Enfer. Here the luxuriance of the vegetation was in strong contrast with the somewhat desolate aspect of the declivities of the Végère.

We entered an immense cave, as large as a great theater, dimly lighted by such rays of the setting sun as found their way through the foliage of a thicket of trees which shaded the entrance. It was empty. Most of the fossil bones it once contained had been used to enrich the fields it overlooked, and the remainder had been carefully removed by M. Lartet. They were especially valuable, for this locality is more ancient than that of Lower Laugerie and others of a similar age.

We had now seen all the prehistoric localities of the Eyzies, with the exception of the Moustier cave, which is a type of the most ancient deposits made by men in the caves when the valley was only partially formed; but this excursion could not be made on foot, and our time was too limited for its accomplishment.

Thanks to the exertions of M. Laganne, from the Eyzies, head workman of MM. Christy and Lartet, the arrangements for the comfort of the excursionists throughout the day were unexceptionable, and as we descended the Vézère in order to reach the ferry near the railroad bridge, we found some ladders placed against the declivity, which enabled us to climb into an artificial cave of several interior stories. In these chambers were niches, mangers for the animals, rings, &c., cut in the rather soft rock. These caves are not rare in this neighborhood. In Corrèze, about Brives, at Lamouron an entire hill is cut into five stories of stalls, large and small, and very irregular in form. Similar excavations are found all over France, and in certain regions, Aisne, for example, are still inhabited. In Dordogne and Corrèze they must be of very ancient date.

At 5 o'clock we retook the train, and our regret, as we rapidly left the valley of the Vézère, was tempered by the pleasant memory of what we had seen and heard. Our locomotive saluted the declivities of Laugerie in passing, and we thought there could not be a more striking demonstration of the law of progress than to speed, with the full power of steam, under the brows of the mountain which had served our savage ancestors as a rendezvous for the chase. See the people of Moustier, hunting the mammoth, the rhinoceros, the bear, and the lion with rude stone implements, held in the hand or imbedded in a heavy spear. Again, long after, when the river had deepened its bed 30 meters, behold their descendants of Upper Laugerie, the gorge d'Enfer, Cromagnon, armed with the bow and arrow. Then civilization commenced; at the Madelaine, the Eyzies, Lower Laugerie, bone was worked into various forms and art was generated. Then appeared a new people, with pottery, domestic animals, and the polished ax; we know the rest. Upon such facts may be based the most happy auspices for the future; a future, it is true, not of nations nor of races, but of humanity.

At Perigueux we dined at the railroad-station, and entered Bordeaux at half past 11 o'clock.

ANCIENT ABORIGINAL TRADE IN NORTH AMERICA.

By Charles Rau.

The following essay was published in German, Vol. V of the *Archiv für Anthropologie* (Braunschweig, 1872); but as the subject is purely North American in character, the author has deemed it proper to prepare a version in the language of the country to which it refers. The present reproduction, however, is enlarged and improved.

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INTRODUCTION.

Indications are not wanting that a kind of trade or traffic of some extent existed among the prehistoric inhabitants of Europe, even at a time when they stood comparatively low in the scale of human development. The same practice prevailed in North America, before that part of the new world was settled by Europeans; and as the the subject of primitive commerce is of particular interest, because it sheds additional light on the conditions of life among by-gone races, I have collected a number of data bearing on the trade-relations of the former inhabitants of North America. The fact that such a trade was carried on is proved, beyond any doubt, by the frequent occurrence of Indian manufactures consisting of materials which were evidently obtained from far distant localities. In many cases, however, these manufactures may have been brought as booty, and not by trade, to the places where they are found in our days. The modern Indians, it is well known, sometimes undertook expeditions of a thousand or twelve hundred miles, in order to attack their enemies. The warlike Iroquois, for example, who inhabited the present State of New York, frequently followed the war-path as far as the Mississippi river. Thus, in the year 1680, six hundred warriors of the Seneca tribe invaded the territory of the Illinois, among whom La Salle sojourned just at that time, preparing to descend the Mississippi to the Gulf of Mexico.* More than a hundred years ago, the traveler

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* Morgan, League of the Iroquois, Rochester, 1851, p. 13. More precise information concerning this memorable expedition is to be found in the writings of Hennepin, Membré, Lahontan, and others.

Carver learned from the Winnebagoes (in the present State of Wisconsin) that they sometimes made war-excursions to the southwestern parts inhabited by Spaniards (New Mexico), and that it required months to arrive there.* Similar excursions and migrations, of course, took place during the early unknown periods of North American history. In the course of such enterprises the property of the vanquished naturally fell into the hands of the victors, who appropriated everything that appeared useful or desirable to them. The consequence was an exchange by force—if I may call it so—which caused many of the manufactures and commodities of the various tribes to be scattered over the face of the country. This having been the case, it is, of course, impossible to draw a line between peaceable barter and appropriation by right of war, and, therefore, while employing hereafter frequently the terms "trade" or "exchange," I interpose that reservation which is necessitated by the circumstances just mentioned.

Of the Indian commerce that has sprung up since the arrival of the Europeans I shall say but little, considering that this subject has sufficiently been treated in ethnological and other works on North America; and I shall likewise omit to draw within the sphere of my observations that interesting trade which was, and still is, carried on between the tribes inhabiting the high north of Asia and America, where Behring's Strait separates the two continents. My attention is chiefly directed to the more ancient manufactures occurring in Indian mounds and elsewhere; and the distribution of these relics over distant parts of the country, in connection with the known or presumed localities which furnished the materials composing them, forms the basis of my deductions. Thus, my essay will assume an *archæological* character, and for this reason I shall confine my remarks to that part of the United States concerning whose antiquities we possess the most detailed information, namely, the area which is bounded by the Mississippi valley (in an extended sense), by the Great Lakes, the Atlantic coast, and the Gulf of Mexico.

A number of archæologists make a distinction between the builders of the extensive mural earthworks and tumuli of North America and the tribes whom the whites found in possession of the country, and consequently separate the relics of the so-called mound-builders from those of the later inhabitants. Such a line of demarcation certainly must appear totally obliterated with regard to the relations which I am about to discuss, for which reason I shall by no means adhere to this vague division in my essay, but shall only advert to the former Indian population in general.

In the following sections I have first treated of a number of materials which formed objects of trade, either in an unwrought state or in the shape of implements and ornaments; and subsequently, in conclusion, I have made some observations tending to add more completeness to my preceding statements.

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* Carver, Travels, &c., Harper's reprint, New York, 1838, p. 42.

COPPER.

Every one knows that the region where Lake Superior borders on the northern part of Michigan abounds in copper, which occurs here in a native state and in immense masses, the separation of which and raising to the surface contribute in no slight degree to the difficulties of the mining process. Long before Europeans penetrated to those parts, the aborigines already possessed a knowledge of this wealth of copper. This fact became known in 1847, at which time the traces of ancient aboriginal mining of some extent were pointed out in that district. The circumstances of this discovery and the means employed by the natives for obtaining the copper being now well known, a repetition of those details hardly would be in place, and I merely refer to the writings relating to this subject.*

Copper was, indeed, the only metal which the North American tribes employed for some purposes before their territories were colonized by Europeans. Traces of wrought silver have been found, but they are so exceedingly scanty that the technical significance of this metal hardly can be taken into consideration. Gold was seen by the earliest travelers in small quantities (in grains) among the Florida Indians;† yet, to my knowledge, no object made of gold, that can with certainty be attributed to the North American Indians, has thus far been discovered.‡ The use of copper, likewise, was comparatively limited, and cannot have exerted any marked influence on the material development of the natives. The copper articles left by the former inhabitants are by no means abundant. As an example I will only mention that, during a sojourn of thirteen years in the neighborhood of St. Louis, which is particularly rich in tumular structures and other tokens of Indian occupancy, I did not succeed in obtaining a single specimen belonging to this class. Copper implements, such as axes, chisels, gravers, knives, and points of arrows and spears, have been found in the Indian mounds and in other places; but most of the objects made of this metal served for ornamental purposes, which circumstance alone would go far to prove that copper played but an indifferent part in the industrial advancement of the race. If the ancient inhabitants had understood the art of melting copper, or, moreover, had nature furnished them with sufficient supplies of tin ore for producing bronze, that peculiar composition which the Mexicans and Peruvians employed, their state of civilization doubtless would have been much higher when the whites arrived in their country. They lacked, however, as far as investigations hitherto have shown, the knowledge of rendering copper serviceable to their purposes by the process of melting, contenting themselves by hammering purely metallic masses of copper with great labor into the shapes of implements or articles of decoration. These masses they doubtless obtained principally, if not entirely, from the copper districts of Lake Superior.* Owing to the arborescent or indented form under which the copper occurs in the above-named region, nearly all copper articles of aboriginal origin exhibit a distinct laminar structure, though quite a considerable degree of density has been imparted to the metal by continued hammering. It must be admitted, furthermore, that the aborigines had acquired great skill in working the copper in a cold state. From an archæological point of view this peculiar application of natural copper is certainly very remarkable, and, therefore, has often been cited, both by American and European writers. To the native population, however, the comparatively sparing use of copper cannot have afforded great material aid, and its chief importance doubtless consisted in the promotion of intercourse among the various tribes.

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* Squier and Davis, Ancient Monuments of the Mississippi Valley, Smithsonian Institution, Washington, 1848. Foster and Whitney, Report on the Geology and Topography of the Lake Superior Land District, Part I, Washington, 1850. Schoolcraft, Indian Tribes of the United States, Vol. I, Philadelphia, 1851. Lapham, The Antiquities of Wisconsin, Washington, 1855. Whittlesey, Ancient Mining on the Shores of Lake Superior, Washington, 1863. Sir John Lubbock, Prehistoric Times, London, 1865, &c.

† See: Brinton, Notes on the Floridian Peninsula, Philadelphia, 1859, Appendix III.

‡ In the Smithsonian Report for 1870, just published, the occurrence of gold beads in a mound near Cartersville, in the Etowah valley, Georgia, is recorded. Native gold is said to be found in the neighborhood, (p. 380.)

The first travelers who visited North America saw copper ornaments and other objects made of this metal in the possession of the natives, and very scrupulously mention this fact in their accounts, while they often leave matters of greater importance entirely unnoticed. This cannot surprise us, considering that the first discoverers were possessed of an immoderate greediness for precious metals, and therefore also paid particular attention to those of less value. The Florentine navigator, Giovanni Verazzano, who sailed in 1524, by order of Francis the First of France, along the Atlantic coast of North America for purposes of discovery, noticed, as he states in his letter to the French king, on the persons of the natives pieces of wrought copper, "which they esteemed more than gold." Many of them wore copper ear-rings.† In the narrative which the anonymous Portuguese nobleman, called the Knight of Elvas, has left of De Soto's ill-fated expedition (1539–'43) it is stated that the Spaniards saw, in the province of Cutifachiqui, some copper axes, or chopping-knives, which apparently contained an admixture of gold. The Indians pointed to the province of Chisca as the country where the people were familiar with the process of melting copper or another metal of a lighter color and inferior hardness.* It is very natural that these gold-seeking adventurers should have anticipated everywhere traces of that valuable metal; and concerning the statements of the Indians in relation to the melting, it is well known how apt the crafty natives always were to regulate their answers according to the wishes of the inquirers. Yet, notwithstanding these improbabilities, the fact remains that the natives of the present Southern States used implements of copper some centuries ago. Indeed, I have seen in the collection of Colonel Charles C. Jones, of Brooklyn, copper articles of the above description, obtained in the State of Georgia. When Henry Hudson discovered, in 1609, the magnificent river that bears his name, he noticed among the Indians of that region pipes and ornaments made of copper. "They had red copper tobacco-pipes, and other things of copper they did wear about their necks." Robert Juet, who served under Hudson as mate in the Half-Moon, relates these details in the journal he has left behind.† Additional statements of similar purport might be cited from the early relations concerning the discovery of North America.

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* Some of the natives of the northernmost part of the United States, lately purchased from Russia, worked copper before the European occupation. Their industry was, of course, entirely independent of that here under consideration. (See, for instance, Von Wrangell, *Russische Besitzungen an der Nordwestküste von Amerika*, St. Petersburg, 1839.)

† The Voyage of John de Verazzano, in Collections of the New York Historical Society, Second Series, Vol. I, New York, 1841, pp. 47 and 50.

While Messrs. Squier and Davis were engaged, more than twenty years ago, in surveying the earthworks of the Mississippi valley, more especially those of the State of Ohio, they found in the sepulchral and so-called sacrificial mounds a number of copper objects, which they have described and figured in the work containing the results of their investigations.‡ They also met small pieces of the unwrought natural metal in some of the mounds. The copper specimens obtained during this survey were formerly in the possession of Dr. Davis, one of the explorers, and I had frequent occasion to examine them. At present they form a part of the Blackmore Museum, at Salisbury, England, to which institute Dr. Davis sold his valuable collection. They are either implements, such as axes, chisels, and gravers; or bracelets, beads, and other probably ornamental objects, exhibiting quite peculiar forms, which were, perhaps, owing to the singular methods employed in fashioning the copper into definite shapes. The axes resemble the flat celts of the European bronze period, and doubtless were fastened in handles like the latter. Some of the bracelets of the better class are of very good workmanship, the simple rods which form them being well rounded and smoothed, and bent into a regular circle until their ends meet. I have seen quite similar bronze bracelets in European collections. The objects just described obviously have been fashioned by hammering; others, however, consisting of hammered copper sheet, received their final shape by *pressure.* To these belong certain circular concavo-convex discs, from one and one-half inches to two inches in diameter, which have been likened to the bosses observed on harnesses. Concerning their use, nothing is definitely known, but it is presumed that they were destined for purposes of ornament. The manipulation of pressure was likewise employed in making smaller articles of decoration resembling the convex metal buttons still seen on the clothes of the peasantry of Germany and other European countries. However, in minutely describing these remarkable products of aboriginal art, I would merely repeat what already has been stated, detailed accounts being given in the well-known work of Messrs. Squier and Davis.

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* Narratives of the Career of Hernando de Soto in the Conquest of Florida, as told by a Knight of Elvas, and in a Relation by Luys Hernandez de Biedma, Factor of the Expedition. Translated by Buckingham Smith. New York, 1866, p. 72.

† Journal of the Voyage of the Half-Moon, in Collections of the New York Historical Society, Second Series, Vol. I, 1841, p. 323.

‡ Ancient Monuments of the Mississippi Valley, pp. 196–207.

Although the fire on the hearths or altars now inclosed by the sacrificial mounds* was sometimes sufficiently strong to melt the deposited copper articles, it does seem that this proceeding induced the ancient inhabitants to avail themselves of fire in working copper; they persisted in the tedious practice of hammering. Yet one copper axe, evidently *cast*, and resembling those taken from the mounds of Ohio, has been ploughed up near Auburn, in Cayuga County, in the State of New York.† This specimen, which bears no traces of use, may date from the earlier times of European colonization. It certainly would be wrong to place much stress on such an isolated case. The Indians, moreover, learned very soon from the whites the art of casting metals. For this we have the authority of Roger Williams, who makes the following statement in reference to the New England Indians; "*They have an excellent Art to cast our Pewter and Brasse into very neate and artificiall Pipes.*"‡

In the Lake Superior district, resorted to by the aboriginal miners, there have been found, besides many grooved stone hammers (sometimes of very large size) and rude wooden tools, various copper implements, such as chisels, gads, &c., and some spear-heads in which, in lieu of a socket, the flat sides at the lower end are partly bent over,§ a feature also peculiar to certain European bronze celts, which, on this account, are denominated "winged" celts.

The copper-lands of Northern Michigan, it has been stated, were visited by the aborigines for the sake of obtaining copper at a period anteceding the arrival of the whites. It is probable that small bands of various northern tribes made periodical excursions to that locality, returning to their homes when they had supplied themselves with sufficient quantities of the much-desired metal. The indications of permanent settlements, namely, burial-places, defensive works, traces of cultivation and dwellings, &c., are wanting, and the small number of chaseable animals, indeed, offered but little inducement to a protracted sojourn. The question, at what time the natives ceased to resort to the mines, has been answered in various ways. Mr. Whittlesey is of opinion that from five to six hundred years may have elapsed since that time, basing his argument on the growth of trees that have sprung up in the rubbish thrown out from the mines; Mr. Lapham, on the other hand, believes in a continuance of the aboriginal mining operations to more recent periods, and thinks they were carried on by the progenitors of the Indians still inhabiting the neighboring parts, although they possess no traditions relative to such labors. Probably as early as the first half of the seventeenth century the French of Canada entertained with those tribes a trade that provided the latter with iron tools, and the ornaments and trinkets so much coveted by the red race. Thus, the inducements to obtain copper ceased, and the practice of procuring it being once discontinued, a few centuries may have sufficed to efface the tradition from the memory of the succeeding generations. Yet, like many other points of North American archæology, this matter is still involved in obscurity, and it would be hazardous, at present, to pronounce any decided opinion on the subject.*

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* For a precise description of the remarkable stratified mounds denominated "sacrificial," I must refer to the "Ancient Monuments of the Mississippi Valley." Burned human bones being often discovered in them in connection with manufactured objects, Sir John Lubbock suggests that these mounds are of a sepulchral rather than a sacrificial character. (Prehistoric Times, first ed., p. 219, &c.)

† Squier, Aboriginal Monuments of the State of New York, Washington, 1849, p. 78.

‡ Roger Williams, A Key into the Language of America; Providence, 1827, p. 55. (Reprint of the London edition of 1643.)

§ Whittlesey, Ancient Mining, &c.

The occurrence of native copper in the United States is not confined to the shore of Lake Superior. As I am informed by Professor James D. Dana, it is also met, in pieces of several pounds' weight, in the valley of the Connecticut river, and likewise, in smaller pieces, in the State of New Jersey, probably originating in both cases from the red sandstone formation. Near New Haven, Connecticut, a mass was found weighing ninety pounds. Such copper finds may have furnished a small part of the metal worked by the aboriginal inhabitants; its real source, however, must be sought, in all probability, in the mining district of Lake Superior. It is a remarkable circumstance that the native copper there occurring sometimes incloses small masses of native silver, a juxtaposition which, as I believe, is not to be observed at any other place in the United States; and just such pieces in which the two natural metals are combined have been taken from a few of the tumuli of Ohio.

Though copper articles of Indian origin are comparatively scarce in

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*The Indians certainly are a forgetful race. The traveler Stephens, who has examined and described the grand ruins of ancient buildings in Yucatan and the neighboring states, maintains—and I believe on good grounds—that these erections, at least in part, are the work of the same Indian populations with whom the conquistadores (Hernandez de Córdova, Grijalva, Cortés) were brought into contact during the sixteenth century. The present descendants of the builders of those magnificent works have preserved no recollections of their more advanced ancestors. Whenever Stephens asked them concerning the origin of the buildings, their answer was, they had been erected by the *antiguos;* but they could not explain their destination; they were unacquainted with the meaning of the statues and fresco paintings, and manifested in general a total ignorance of all that related to their former history.

the United States,* the field of their distribution, nevertheless, is very wide, extending from the Great Lakes to the Gulf States, and from the Atlantic coast to the Mississippi, and, perhaps, some distance beyond that river. Taking it for granted, as we may do, that the northern part of Michigan is the point from which the metal was spread over that area, the traffic in copper presents itself as very extensive as far as distance is concerned. The difficulties connected with the labor of obtaining this metal doubtless rendered it a valuable object, perhaps no less esteemed than bronze in Europe, when the introduction of that composition was yet of recent date. The copper probably was bartered in the shape of raw material. Small pieces of this description, I have already stated, were taken from the mounds of Ohio, and larger masses occasionally have been met in the neighborhood of these works. One mass weighing twenty-three pounds, from which smaller portions evidently had been detached, was discovered in the Scioto valley, near Chillicothe, Ohio.† Of course, it is impossible at present to demonstrate in what manner the copper trade was carried on, and we have to rest satisfied with the presumption that the raw or worked copper went from hand to hand in exchange for other productions of nature or art, until it reached the places where we now find it. Perhaps there were certain persons who made it their business to trade in copper. I must not omit to refer here to some passages bearing, though indirectly, on the latter question, which are contained in the old accounts of Hernando de Soto's expedition. Garcilasso de la Vega speaks of wandering Indian merchants (*marchands*), who traded in salt.‡ The Knight of Elvas is still more explicit on this point. According to him, the Indians of the province of Cayas obtained salt by the evaporation of saline water. The method is accurately described. They exported salt into other provinces, and took in return skins and other commodities. Biedma, who accompanied that memorable expedition as accountant, likewise speaks in various places of salt-making among the Indians.§

GALENA.

It has been a common experience of discoverers that the primitive peoples with whom they came in contact manifested, like children, a remarkable predilection for brightly-colored and brilliant objects, which, without serving for any definite purpose, were valued merely on account of their external qualities. The later North American Indians exhibited this tendency in a marked degree, and their predecessors, whose history is shrouded in darkness, seem to have been moved by similar impulses. Thus the common ore of lead, or galena, was much prized by the former inhabitants of North America, though there is, thus far, no conclusive evidence of their having understood how to render it serviceable by melting. Quite considerable quantities of this shining mineral have been met in the mounds of Ohio. On the hearth of one of the sacrificial mounds of that State, Messrs. Squier and Davis discovered a deposit of galena, in pieces weighing from two ounces to three pounds, the whole quantity amounting perhaps to thirty pounds. The sacrificial fire had not been strong enough to convert the ore into pure metal, though some of the pieces showed the beginning of fusion.* As stated before, there is no definite proof that the aborigines were acquainted with the process of reducing lead from its ore; for as yet no leaden implements or ornaments have been discovered that can be ascribed with certainty to the former population. The peculiarly shaped object of pure lead figured on page 209 of the "Ancient Monuments," which came to light while a well was sunk within the ditch of the earthwork at Circleville, Ohio, was perhaps made by whites, or by Indians at a period when they already had acquired from the former the knowledge of casting lead. This curious relic is in possession of Dr. Davis, and I have often examined it. The archæological collection of the Smithsonian Institute contains not a single Indian article of lead, but quantities of galena, which were taken from various mounds. Yet, supposing the Indians had known the fusibility of galena, the lead extracted therefrom could not have afforded them great advantages, considering that its very nature hardly admitted of any useful application. "Too soft for axes or knives, too fusible for vessels, and too soon tarnished to be valuable for ornament, there was little inducement for its manufacture."—(Squier and Davis.) However, in making net-sinkers, it would have been preferable to the flat pebbles notched on two opposite sides, which the natives used as weights for their nets. Pebbles of this description abound in the valley of the Susquehanna and in various other places of the United States, especially in the neighborhood of rivers.

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* The Smithsonian Institution has been receiving for years Indian antiquities from all parts of North America, yet possessed in 1870 only seven copper objects; namely, three spearheads, two small rods, a semilunar knife with convex cutting edge, and an axe of good shape. Professsor Baird was kind enough to send me photographs and descriptions of these articles.

† Ancient Monuments, &c., p. 203.

‡ Conquête de la Floride, Leide, 1731, Vol. II, p. 400.

§ Narratives of the Career of Hernando de Soto, &c., p. 124. Biedma, pp. 152, 153, and 257.

The frequent occurrence of galena on the altars of the sacrificial mounds proves, at any rate, that the ancient inhabitants attributed a peculiar value to it, deeming it worthy to be offered as a sacrificial gift. The pieces of galena found in Ohio were, in all probability, obtained in Illinois or Missouri, from which regions they were transferred by way of barter, as we may presume, to the Ohio valley. No original deposits of galena are known in greater proximity that could have furnished pieces equal to those taken from the mounds of Ohio.

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*Ancient Monuments, pp. 149 and 209.

OBSIDIAN.

The peculiar glass-like stone of volcanic origin, called obsidian, which played such an important part in the household of the ancient Mexicans, has not been met *in situ* within that large portion of the United States (probably of North America in general) that lies north of Mexico and to the east of the Rocky Mountains. Messrs. Squier and Davis, nevertheless, have found obsidian in the shape of points for arrows and spears and cutting implements, though mostly broken, in five mounds of the Scioto valley, in Ohio; an object made of this material was likewise found in Tennessee,* and the numerous unopened mounds of the United States may inclose many more articles of this class. The copper used by the Indians, it has been seen, occurs as a product of nature within the area over which it was spread by human agency; it is different, however, with regard to obsidian, and the question therefore arises, from what region the builders of the large inclosures and tumuli in Ohio obtained the last-named mineral. Obsidian, we know, is found in the present territory of the United States on the western side of the Rocky Mountains. Captain Bonneville noticed, about forty years ago, that the Shoshonees or Snake Indians in the neighborhood of Snake river (or Lewis river) used arrows armed with points of obsidian, which, he adds, abounds in that vicinity.† The latter fact is confirmed by Samuel Parker, who found, some years later (1835), in the volcanic formations of that region, "many large and fine specimens of pure obsidian or volcanic glass."‡ According to Wyeth, the Shoshonees also employ sharp obsidian flakes of convenient shape as knives, which they sometimes provide with handles of wood or horn. The same author mentions the frequent occurrence of obsidian in the district inhabited by the Shoshonees.§ It is known that various tribes in New Mexico, Arizona, and neighboring parts, Apaches, Mojaves, and others, frequently employ obsidian in the manufacture of their arrowheads.

Mr. John R. Bartlett, from 1850 to 1853 commissioner of the United States for determining the boundary line between the latter and Mexico, found pieces of obsidian and fragments of painted pottery along the Gila river, wherever there had been any Indian villages; and also among the ruins of the *Casas grandes*, in Chihuahua, as well as those of the Gila and Salinas rivers.|| The same observation has been made by earlier and later travelers. The natives of Upper California employ obsidian extensively for making arrowheads. Mr. Caleb Lyon, who

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* Troost, Ancient Remains in Tennessee, in: Transactions of the American Ethnological Society, New York, 1845, Vol. I, p. 361.

† Irving, Adventures of Captain Bonneville, New York, 1851, p. 255.

‡ Parker, Exploring Tour beyond the Rocky Mountains, Ithaca, New York, 1844, p. 98.

§ Wyeth, in Schoolcraft's Indian Tribes, Vol. I, p. 213.

|| Bartlett, Personal Narrative, &c., New York, 1854, Vol. II, p. 50. Compare: Humboldt, Essai politique sur la Nouvelle-Espagne, Paris, 1825, Vol. II, p. 243, and Clavigero, History of Mexico, Philadelphia, 1817, Vol. I, p. 151.

was, about ten years ago, among the Shasta Indians in California, saw one of the tribe engaged in making arrowheads from obsidian as well as from the glass of a broken porter-bottle. He describes the method of manufacture in a letter which was published by the American Ethnological Society.* To this letter I shall refer in a succeeding section of this essay, when treating of the division of labor among the North American Indians. Mr. Bartlett visited, while in California, a locality in the Napa valley (north of San Francisco), where obsidian occurs in pieces from the size of a pea to that of an ostrich egg, which are imbedded in a mass resembling a coarse mortar of lime, sand, and gravel. He found the surface in many places covered, from six to twelve inches in depth, with broken pieces and small boulders of this volcanic substance. The appearance of these spots reminded him of a newly-made macadamized road.†

The most extensive use of obsidian, however, was formerly made in Mexico, before the empire of the Aztecs succumbed to the Spanish invaders. Old obsidian mines are still seen on the *Cerro de Navajas*, or "Hill of Knives," which is situated in a northeasterly direction from the city of Mexico, at some distance from the Indian town Atotonilco el Grande. These mines provided the ancient population of Mexico with vast quantities of the much-prized stone, of which they made those fine double-edged knives, arrow and spear-heads, mirrors, very skilfully executed masks, and ornaments of various kinds. Humboldt speaks of the Hill of Knives in a transient manner;‡ for a precise description we are indebted to the meritorious English ethnologist, E. B. Tylor, who visited that interesting locality in 1856, while traveling through Mexico in company with the late Mr. Christy.§ In describing the mines, Mr. Tylor says: "Some of the trachytic porphyry which forms the substance of the hills had happened to have cooled, under suitable conditions, from the molten state into a sort of slag, or volcanic glass, which is the obsidian in question; and, in places, this vitreous lava, from one layer having flowed over another which was already cool, was regularly stratified. The mines were mere wells, not very deep, with horizontal workings into the obsidian where it was very good and in thick layers. Round about were heaps of fragments, hundreds of tons of them; and it was clear, from the shape of these, that some of the manufacturing was done on the spot. There had been great numbers of pits worked, and it was from these *minillas*, little mines, as they are called, that we first got an idea how important an element this obsidian was in the old Aztec civilization. In excursions made since, we traveled over whole districts in the plains where fragments of these arrows and knives were to be found literally at every step, mixed with morsels of pottery, and here and there a little clay idol."*

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* Bulletin of the American Ethnological Society, New York, 1861, Vol. I, p. 39.

† Personal Narrative, Vol. II, p. 49.

‡ Essai politique sur la Nouvelle-Espagne, Vol. III, p. 122.

§ Tylor, Anahuac: or Mexico and the Mexicans, Ancient and Modern, Lond., 1861. This volume contains, besides many facts relating to the archæology and ethnology of Mexico, the best observations on obsidian I have found in any work on that country.

From the centre of the State of Ohio to the country of the Shoshonees, as well as to the Rio Gila, and the just-described mines in Mexico, the straight distances are almost equal, measuring about seventeen hundred English miles; indeed, the Mexican mines are a trifle nearer to Ohio than the above-mentioned districts. It would be lost labor, therefore, to indulge in speculations from which of these localities the obsidian found in Ohio and Tennessee was derived. The number of articles of this stone that has been met east of the Mississippi is so exceedingly small that its technical significance hardly deserves any consideration. Yet, the sole fact of finding worked obsidian at such great distances from the nearest places where it occurs either *in*

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* Anahuac, p. 99. The following interesting communication was addressed to me by Dr. C. H. Berendt:

"During one of many excursions which I made in the years 1853-'56 around the Citlaltepetl, or Pico de Orizaba (in the State of Vera Cruz), I saw an obsidian mine on the western slope of that mountain. I had heard of it from my friend the late Mr. C. Sartorius ,who had visited the place years ago. I was informed that the Indians of the village of Alpatlahua knew the place, but that they did not like to have it visited. Some say they have treasures hidden in the caves of the neighborhood; while others believe that they have idols in those lonely places which they still secretly worship. The cura of San Juan Coscomatepec, who was of this latter opinion, gave me the name of a mestizo farmer in the neighborhood who might be induced to show me the place. Our party followed from Coscomatepec the road which leads to the rancho Jacal and the pass of La Cuchilla. We did not find the mestizo at home, but his wife, who directed her boy to show us the cave. Reaching the bridge of the Jamapa river, we took a by-road parting to the north, which brought us to the village of Alpatlahua, and about four miles farther north to a branch of the Jamapa river, which we crossed. We then left the road and proceeded about half a mile up the river through thick woods, when we found ourselves suddenly before the entrance of the cave. It was about fifty feet high and of considerable width, but obstructed by fallen rocks and shrubs. Heaps of obsidian chips of more than a man's height filled the bottom of the grotto, which had apparently no considerable horizontal depth. To the left the mine was seen, an excavation of from six to eight square yards, the bottom filled up with rubbish and chips. Obsidian, evidently, had not only been quarried, but also been made into implements at this spot, the latter fact being proved by the occurrence of cores, or nuclei, of all sizes, from which flakes or knives had been detached. We were not prepared for digging, and it was too late for undertaking explorations that day. So we left, with the purpose to return better prepared at another time, hoping to find some relics of the miners and workmen, and, perhaps, other antiquities. But it happened that I never had an opportunity to visit the place again. Mr. Sartorius saw in this cave three entrances walled up with stone and mortar, but these I did not discover, having, as stated, no time for a careful examination. Future travelers, I hope, will be more successful.

"Mr. Sartorious mentioned another place, likewise in the State of Vera Cruz, where obsidian formerly was quarried. This place is situated in the chain of mountains extending from the Pico de Orizaba to the Cofre de Perote. One of the intervening mountains, called Xalistac, is distinguished by a white spot that can be seen at the distance of many miles, even at Vera Cruz. It is produced by an outcropping of pumice-stone resting on an immense mass of obsidian that has been worked in various places. I know the mountain well, but not the road leading to it, never having traveled in that direction."

situ or in consequence of human agency (as, perhaps, on the Gila), is in itself of importance, for it furnishes an additional illustration of the far-reaching communications among the aborigines of North America.

MICA.

Like the shining galena, mica (commonly called isin-glass), was a substance held in high estimation by the former inhabitants; but, while the first-named mineral apparently fulfilled no definite purpose, being deemed valuable merely for its brilliancy, the latter was often made into articles of ornament, a purpose for which it certainly was well fitted on account of its metallic lustre. It is also said to have been used for mirrors. Mica is found in the tumuli in considerable quantities, sometimes in bushels, and is often ploughed up in the neighborhood of old earthworks. It occurs in sepulchral mounds as well as, though more rarely, in those of supposed sacrificial character. In the former the plates of mica are placed on the chest or above the head of the skeleton, and sometimes they cover it almost entirely. If I speak here of "plates of mica," the expression is to be taken literally, it being known that this mineral occurs in some of the eastern parts of North America in masses of considerable size, as, for instance, in New Hampshire, where pieces of from two to three feet in diameter have been observed.

The most important archæological finds of mica, as far as I know, occurred in Ohio. Of some of them I will give here a brief account.

Mr. Atwater has left a very accurate description of the earthwork at Circleville, Ohio, now mostly obliterated, which consisted of a large circular and adjoining quadratic embankment. In the centre of the circle there arose a sepulchral mound which contained two skeletons and various objects of art, among which was a "mirror" of mica, about three feet long, one foot and a half wide, and one inch and a half in thickness. Atwater found these so-called mirrors at least in fifty different places in Ohio, mostly in mounds. "They were common among that people," he says, "and answered very well the purpose for which they were intended. These mirrors were very thick, otherwise they would not have reflected the light."* It has been doubted, however, whether the objects served as mirrors. It is true, every one who has come in contact with the modern Indians knows how eager they are, prompted by vanity, to obtain from the traders small looking-glasses, which they often carry about their persons in order to contemplate their features, or to have them on hand when they are about to paint their faces, or to eradicate their scanty growth of beard. Yet, after all, I am inclinded to believe that Atwater's so-called mirrors were nothing else but those large plates of mica, probably of symbolic character (as will be seen), which have frequently been met since the publication of his account.

In the year 1828, during the digging of a canal near Newark, Ohio, one of the low mounds frequent in that neighborhood was removed. It contained fourteen skeletons in a high state of decomposition, which were covered with a regular layer of mica plates. The latter were from eight to ten inches in length, four or five inches wide, and from half an inch to an inch in thickness. The quantity of mica thrown up from this mound amounted to *fifteen or twenty bushels.*[*]

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* Atwater, in: Archæologica Americana, Worcester, 1820, Vol. I, pp. 178, 225.

During their archæological investigations, Messrs. Squier and Davis frequently found mica in the mounds, and they have given precise accounts of their discoveries. In one of the sacrificial mounds near Chillicothe, Ohio, they came upon a layer of round plates of silvery mica, measuring from ten to twelve inches in diameter, which overlapped each other like the tiles or slates on a roof, and were deposited in the shape of a half-moon. The excavation laid bare more than one-half of this crescent, which could not have measured less than twenty feet from horn to horn. The greatest width (in the middle) was five feet. It has been thought that the shape of this curious deposit of mica might be suggestive of the religious views of the builders of the mound, and imply a tendency to moon-worship.[†] Another mound not far from the preceding one—both belonged to a group of twenty-three within an inclosure—likewise contained mica.[‡] The circular cavity of the altar in this mound was filled with fine ashes intermixed with fragments of clay vessels and some small convex copper discs. Over these contents of the basin a layer of mica sheets, overlapping each other, was spread like a cover, which, again, served as the basis for a heap of burned human bones, probably belonging to a single person.[§]

The authors of the "Ancient Monuments" also found occasionally in the mounds ornaments made of thin sheets of mica, cut out very neatly and with great regularity in the shapes of scrolls, oval plates, and discs, and pierced with small holes for suspension or attachment. They doubtless were intended to embellish the dress of persons of distinction.[‖] Dr. Davis has some of these ornaments which, fastened on black velvet, almost might be taken for silver objects, the mica of which they are made being of the perfectly opaque kind. Ornamental plates of mica, further, were met in the large Grave-Creek Mound, situated twelve miles below Wheeling, in Western Virginia. This burial-mound, which is one of the highest in the United States—it is seventy feet high—was opened in 1838. Near one of the skeletons, one hundred and fifty rather irregularly-shaped thin sheets of mica, from one inch and a half to two inches in size, were collected. They were all provided with two or more holes for stringing them together, and had evidently formed a scarf or some other article of personal adornment.[¶]

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[*] Ancient Monuments, p. 72.

[†] Ancient Monuments, p. 154.

[‡] This earthwork, called "Mound City" by Squier and Davis, will be described in a subsequent section.

[§] Ancient Monuments, p. 145.

[‖] Ancient Monuments, p. 155; representations on p. 240.

[¶] Schoolcraft, in: Transactions of the American Ethnological Society, Vol. I, p. 399.

The preceding quotations, to which others of similar purport might be added, will suffice to show how much mica was valued by the former inhabitants of the Mississippi valley; indeed, the frequent and peculiar occurrence of this mineral in the mounds almost might justify the conjecture that it was believed to be invested with some mysterious significance, and played a part in the superstitious rites of the aborigines. Mica has been found in a worked and raw state in districts where it is not furnished by nature, and therefore may be safely classed among the aboriginal articles of exchange. In the State of Ohio, to which my observations chiefly refer, mica is not found *in situ*, and it is presumed that the mineral discovered in that State was derived from the southern spurs of the Alleghany Mountains. Yet, it may have been brought from greater distances, and from various points, to its present places of occurrence.

SLATE.

Various kinds of ancient Indian stone manufactures frequently consist of a greenish slate, which is often marked with darker parallel or concentric stripes or bands, giving the objects made of it a very pretty appearance. This slate is not very hard, but of close grain and therefore easily worked and polished. The objects made of this stone, which occur on the surface as well as in mounds, are generally executed with great care and regularity, and it is much to be regretted that the destination of some of them is not quite well known. Among the latter are certain straight tubes of cylindrical and other shapes and various lengths, which sometimes terminate in a kind of "mouth-piece." While the smaller ones, which often measure only a few inches, have been thought to represent articles of ornament, or amulets, a different purpose has been ascribed to the longer specimens. Schoolcraft appears to consider these latter as telescopic instruments which the ancient inhabitants used for observing the stars. This view, I think, has been generally rejected. It is far more probable that these tubes, in part at least, were implements of the sorcerers or medicine-men, who employed them in their pretended cures of diseases. They applied one end of the tube to the suffering part of the patient and sucked at the other end, in order to draw out, as it were, the morbid matter, which they afterwards feigned to eject with many gesticulations and contortions of the body. Coreal calls the tubes used by the medicine-men of the Florida Indians a kind of shepherd's flute (*une espèce de chalumeau*) and the character of some of the stone implements in question that have been found certainly justifies this comparison.* Kohl saw, as late as 1855, one of the above-mentioned cures performed among the Ojibways of Lake Superior; in this instance, however, the tube used by the medicine-man was a smooth hollow bone, probably of the brant-goose.*

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* Coreal, Voyages aux Indes Occidentales, Amsterdam, 1722, Vol. I, p. 39.

A far more numerous class of articles often made of the greenish striped slate is represented by small, variously-shaped tablets of great regularity and finish, which are pierced in the middle with one, two, or more round holes. The most frequent shape of these tablets is illustrated by the upper figure on Plate 28 in Vol. I of Schoolcraft's work on the Indian tribes. It is that of a rectangle with sides exhibiting a slight outward curve. The full-size drawing of this rather large specimen is done in colors, and thus affords the advantage of showing the greenish tint and the markings of the stone. Other tablets are lozenge-shaped, quadratic with inwardly-curved sides, oval, cruciform, &c.† Most of them have two perforations, though specimens with only one are not scarce, while those that have more than two holes are of less frequent occurrence. The holes are drilled either from one side or from both, and, accordingly, of conical or bi-conical shape. They seldom have more than one-eighth of an inch in diameter at the narrowest part. Concerning the destination of the tablets nothing is definitely known. At first sight one might be inclined to consider them as objects of ornament or as badges of distinction; but this view is not corroborated by the appearance of the perforations, which exhibit no traces of the wear produced by continued suspension, being, on the contrary, in most cases as perfect as if they had but lately been drilled. The classification of the tablets as "gorgets," therefore, may be regarded as erroneous. Schoolcraft calls them implements for twine-making. It has been suggested that they were used in condensing and rounding bow-strings by drawing the wet strips of hide, or the sinews employed for that purpose, through the round perforations. The diameter of the latter, it is true, corresponds to the thickness of an ordinary Indian bow-string; but also in this case the usually unworn state of the holes rather speaks against this supposition.

Being desirous to learn whether Mr. George Catlin had seen, during his first sojourn among the western tribes, anything like those tablets used by them in making bow-strings, I availed myself of that gentleman's return to the United States, and asked him by letter, among other matters, for information concerning this subject. He replied (December 24, 1871) as follows:

"Of the tablets you speak of, I have seen several, but the holes were much larger than those you describe. Those that I have seen were used by the Indians for grooving the shafts of their arrows. All arrows of the primitive Indians are found with three grooves from the arrow's shoulder, at the fluke, extending to, and conducting the air between, the feathers, to give them steadiness. These grooves, on close examination, are found to be indented by pressure, and not in any way cut out; and this pressure is produced, while forcing the arrow, softened by steam, through a hole in the tablet, with the incisor of a bear set firmly in a handle and projecting over the rim of the hole as the arrow-shaft is forced downward through the tablet, getting compactness, and on the surface and in the groove a smoothness, which no cutting, filing, or scraping can produce. It would be useless to pass the bow-string through the tablet, for the evenness and the hardness of the strings are produced much more easily and effectually by rolling them, as they do, between two flat stones while saturated with heated glue."

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* Kohl, Kitschi-Gami, oder Erzählungen vom Obern See, Bremen, 1856, Vol. I, p. 148. Compare: Venegas, History of California, London, 1759, Vol. I, p. 97, and Baegert's Account of the Aboriginal Inhabitants of the Californian Peninsula, Smithsonian Report for 1864, p. 386. Drawings of the stone tubes are given on pp. 224–27 of the "Ancient Monuments of the Mississippi Valley."

† The various shapes of these tablets, and of other perforated objects, not exactly tablets, but probably intended for the same purpose, are represented on pages 236 and 237 of the "Ancient Monuments."

Thus, Mr. Catlin's experience is rather unfavorable to the supposition that the pierced stone tablets mentioned by me were used in condensing bow-strings. Yet, after all, they probably served for some similar purpose, which may be clearly defined hereafter by continued examination and comparison. I regard them as implements, and not as objects of ornament or distinction.*

The greenish slate is frequently the material of another numerous class of Indian relics of enigmatical character. I allude to those curious articles bearing a distant resemblance to a bird, which are pierced at the base with diagonal holes, evidently for suspension, the traces of wear being distinctly visible. They probably represent insignia or amulets. I have also heard the suggestion that they were used for removing the husk of Indian corn.†

Of much rarer occurrence than the articles thus far enumerated in this section are perforated implements somewhat resembling an axe with two cutting edges, or, more often, a double pick-axe, which, doubtless, were provided with handles and worn as badges of distinction by the superiors.‡ These objects are for the most part elegantly shaped, but of small size, and cannot have been applied to any practical use, their material, moreover, consisting generally of soft stone, more particularly of the greenish slate in question. It is evident, therefore, that they fulfilled a symbolical purpose, and were employed in the manner just mentioned.

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*The Smithsonian Report for 1870, which has appeared since the above was written, contains, among other ethnological matter, an account of an exploration of mounds in Kentucky, by Mr. Sidney S. Lyon. Among the contents of one of the mounds was "a black stone with holes through it." *I have seen this kind of an instrument*, says Mr. Lyon, *used by the Pah-Utes of Southeastern Nevada, for giving uniform size to their bow-strings.* (p. 404.)

† A group of these singular objects is represented on page 239 of the "Ancient Monuments."

‡ Schoolcraft gives on Plate 11, Vol. I, of his large work, two colored half-size representations of such implements, which he calls "maces."

Having now briefly described the most important classes of relics made of the striped slate, I pass over to the principal point of inquiry, namely, the extent of their occurrence. I know from personal experience that they are found from the Atlantic coast to the Mississippi river, a distance about equal to one-third of the whole breadth of the United States. It is possible that they are scattered over a far greater area. In 1848, when Squier and Davis published their work, in which aboriginal manufactures were for the first time accurately described, they could not specify the locality from which the oft-mentioned slate was derived. Since that time geological surveys have been made in all States of the Union, and the places of its occurrence are no longer unknown. It appears, I am informed, as the oldest sedimentary formation, in quite considerable masses along the Atlantic coast, and has been observed from Rhode Island to Canada. This slate is not believed to occur in other parts of the Union, and it may be presumed, therefore, that it was brought from the Atlantic coast-districts, either in a rough or already worked condition, to the more western regions of the United States.

FLINT.

The real flint (*Feuerstein* in German) which is found abundantly, in rounded pieces or nodules in the cretaceous formations of the countries bordering on the Baltic, of England, France, &c., and which has played such an important part in the prehistoric ages of Europe, does not seem to occur within the United States. For this information I am personally indebted to Professor James D. Dana. On the other hand, many parts of this country are very rich in various kinds of stones of a silicious character, which, in consequence of their hardness and conchoidal fracture, were well fitted to replace the missing variety in the production of chipped implements. The term "flint," therefore, is used here in a rather extensive sense, comprising hornstone, jasper, chalcedony, ferruginous quartz, sweetwater quartz, milky quartz, semi-opalic stones, &c., and the numerous transitions from one quartzy variety into another, for which the science of mineralogy has no special denominations. The common white quartz, also, I may remark in this place, and the transparent rock-crystal, were used for pointing arrows; and in districts where harder stones were scarce, even slates and greenstones served as substitutes for them in the fabrication of arrow and spearheads.

As in Europe, so also in the United States, places have been discovered where the manufacture of flint implements was carried on. These "open-air workshops" (*ateliers en plein air*) are by no means rare in North America, and they begin to attract considerable attention since the successful archæological researches in Europe have stimulated to similar pursuits in this country. As the North American tribes all used the bow, and consequently were in constant need of arrowheads, the manufacture of the latter took place in many localities, especially in such as furnished the stones most proper for that purpose. The *Kjoek-*

kenmoedding at Keyport, New Jersey, described by me in the Smithsonian Report for 1864, evidently was one of the places where flint implements were made by the natives. I not only saw there among the shell-heaps countless chips of flint, but found also a number of unfinished arrowheads, which had been thrown aside on account of a wrong crack or some other defect in the stone. The necessary material was here furnished on the spot, in the shape of innumerable water-worn pebbles of silicious character, which lie intermixed with the shells. Among the unfinished arrowheads picked up by me at this place there are some which exhibit a part of the smooth water-worn surface of the pebble from which they were made.

In the middle part of the Mississippi valley, where I lived many years, and had occasion to make various observations, the Indians were amply provided by nature with the material employed in the fabrication of spear and arrowheads. The prevailing rock of those regions is a limestone in which several of the varieties of the quartz family are found, either in layers or in irregular concretions. In the bluff formations of the "American Bottom" in Illinois, for instance, I have traced myself layers of hornstone, chalcedony, &c., for the distance of miles. In the districts under notice, moreover, the surface is covered here and there with many silicious pebbles and boulders, which furnished an inexhaustible supply of available material.

An important locality to which the aborigines resorted, perhaps from great distances, for quarrying flint, is in Ohio, on the line of a calcareo-silicious deposit, called "Flint Ridge," which extends through Muskingum and Licking Counties of that State. "The compact silicious material of which this ridge is made up," says Dr. Hildreth, "seems to have attracted the notice of the aborigines, who have manufactured it largely into arrow and spearheads, if we may be allowed to judge from the numerous circular excavations which have been made in mining the rock, and the piles of chipped quartz lying on the surface. How extensively it has been worked for these purposes, may be imagined from the countless number of the pits, experience having taught them that the rock recently dug from the earth could be split with more freedom than that which had lain exposed to the weather. These excavations are found the whole length of the outcrop, but more abundantly at 'Flint Ridge,' where it is most compact and diversified with rich colors."*

The Indian working-places of which I spoke are not always met in the neighborhood of those spots where flint was quarried or otherwise abundant, but also sometimes at considerable distances from the latter, in which cases they are, of course, of comparatively small extent. Their existence, however, proves that the material was transported from place to place, and thus assumed the character of a ware. Colonel

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* Hildreth, in Mather's First Annual Report on the Geological Survey of the State of Ohio, Columbus, 1838, p. 31.

Charles C. Jones, of Brooklyn, who has paid particular attention to the former history of his native State Georgia, informed me he had observed quantities of silicious stone, surrounded by numerous rejected fragments and unfinished spear and arrowheads of the same material, in districts of that State where far and near no quartz minerals occur *in situ*. He showed me a number of these incomplete flint objects obtained from such places.

For the fact that stones for arrowheads formed an object of traffic among the natives, even historical evidence is not wanting. I refer to a passage in the relation of Cabeça de Vaca, the first European who has given an account of the interior of North America. The passage in question will be quoted in a subsequent section.

I am of opinion that flint in a half-worked state, that is, in flattish pieces roughly chipped around their circumference and presenting irregular heart-shaped, oval, or round outlines, formed an object of exchange, and as such was transported to places far distant from the sites which furnished the raw material. Those who quarried the flint fashioned it in this manner for the sake of saving space and for easier transportation. Smaller or greater quantities of such worked flint fragments of homogeneous character are sometimes found in the earth, where the natives had buried them, believing that flint splits more readily when recently taken from the ground. These deposits, however, are not always composed of pieces which required further chipping in order to receive their final shape, but also sometimes of finished implements. I have treated of these buried deposits of flint objects in an article published in the Smithsonian Report for 1868, to which I refer in order to avoid repetitions.* The agricultural implements of East St. Louis, described in that article, are very skilfully executed manufactures of the aborigines; the large flint discs, on the contrary, which, as I mentioned, Messrs. Squier and Davis found in great number in a mound of "Clark's Work" in Ohio, and the rude flint objects of elongated oval outline from the bank of the Mississippi between St. Louis and Carondelet, present, in all probability, only rudimentary forms of implements, and were destined to be finished at a future time. It cannot be doubted that the stone of which the discs of Clark's Work are made was derived from the quarries of Flint Ridge. This fact has been established by careful comparisons. The stone in question is designated as hornstone. It is a beautiful material, resembling in color and grain certain varieties of the real European flint, and is sometimes marked with darker or lighter concentric bands, the centre of which is formed by a small nucleus of blue chalcedony. These bands are particularly observable on the surfaces which have undergone a change of color by exposure. The stone, in general, possesses qualities by which it can be recognized at once, even when met in a wrought state far from its original place of occurrence. According to Mr. Squier, arrowheads made of this hornstone have been found in Kentucky, Indiana, Illinois, and Michigan. That they occur in Illinois, I can attest from personal experience.

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* A Deposit of Agricultural Flint Implements in Southern Illinois, p. 401.

A very remarkable find of objects manufactured from the hornstone of Flint Ridge occurred in the summer of 1869 on the farm of Oliver H. Mullen, near Fayetteville, in St. Clair County, of the State of Illinois. Some children, amusing themselves near the barn of that farm, happened to dig into the ground, and came upon a deposit of fifty-two disc-like flint implements, which lay closely heaped together. I obtained a number of these implements through my indefatigable co-laborer, Dr. Patrick, of Belleville, Illinois. They coincide in shape with those of Clark's Work, but are somewhat smaller, and not, like the latter, superficially prepared objects, but highly-finished implements. This fact is shown by the careful chipping of the edges, to which sharpness and roundness have been imparted by small and carefully measured blows. Unlike the deposit of East St. Louis, which consisted of perfectly new implements, that of Fayetteville was made up of such as had already done service. To this conclusion I am lead by the character of their edges, which exhibit a slight wear or polish. I regard these implements as *scraping* or *smoothing tools*, to which purposes they were well adapted by their shape; and I have but little doubt that the less finished discs of Clark's Work were to be converted, by further chipping, into implements of the same kind.

In connection with the object, however, which I have in view in this essay, the identity of the stone of Flint Ridge with that of which the tools found at Fayetteville in Illinois consist, is the point that deserves particular consideration. This identity admits of no doubt. I was convinced of it at first sight when I received the implements from Fayetteville, and so were Messrs. Squier and Davis, to whom I showed my specimens. The direct distance from the quarries at Flint Ridge to Fayetteville is about four hundred English miles, and thus far, at least, the stone was exported, in a rudimentary or finished shape, from its original site. So much is certain; but it is not unlikely that implements made of this hornstone will be found hereafter at still greater distances from the quarries in Ohio.

RED PIPESTONE.

The celebrated red pipestone, that highly-valued material employed by the Indians of past and present times in the manufacture of their calumets, occurs *in situ* on the Coteau des Prairies, an elevation extending between the Missouri and the headwaters of the Mississippi. This is the classical ground of the surrounding tribes, and many legends lend a romantic interest to that region. It was here that the Great Spirit assembled the various Indian nations and instructed them in the art of making pipes of peace, as related by Longfellow in his charming "Song of Hiawatha." Even hostile tribes met here in peace, for this district was, by common consent, regarded as neutral ground, where strife and feuds were suspended, that all might resort unmolested to the quarry and supply themselves with the much-prized red stone. This material, though compact, is not hard, and therefore easily worked, and, moreover, capable of a high polish. It consists chiefly of silica and alumina, with an admixture of iron, which produces the red color. American, and probably also European, mineralogists call this stone Catlinite, in honor of the zealous ethnologist and painter, Catlin, who was the first to give an accurate account of its place of occurrence, and to relate the traditions connected with the red pipestone quarry.* This locality is the only one in North America where this peculiar stone is found, and it is doubtful, indeed, whether in any other place on both hemispheres a mineral substance is met which corresponds in every respect to the one in question.

The enterprising Jesuit missionary, Marquette, whose name is forever linked with the exploration of the Mississippi, smoked already in the year 1673 the pipe of peace with the Illinois Indians, and gives the following exact description of that important utensil, the bowl of which, it will be seen, consisted of the red stone of Coteau des Prairies. "It is made of a polished red stone, like marble, so pierced that one end serves to hold the tobacco, while the other is fastened on the stem, which is a stick two feet long, as thick as a common cane, and pierced in the middle; it is ornamented with the head and neck of different birds of beautiful plumage; they also add large feathers of red, green and other colors, with which it is all covered."† His ecclesiastical successors also frequently mention the red pipes in their writings, but none of them, as far as I know, alludes to the locality where the stone was obtained. The first notice referable to that place, I found in the "History of Louisiana" by DuPratz, and even his statement is totally erroneous as far as the situation of the quarry is concerned. "On the bank of the Missouri," he says, "there is to be seen a pretty high cliff (*écore*), which rises so abruptly from the water that the nimblest rat could not climb it. From the middle part of this cliff projects a mass of red stone, which is marked with white spots like porphyry, from which it differs, however, by inferior hardness, being almost as soft as tufa. It is covered by another kind of stone of no value, and rests upon the same sort of earth that forms the other hills. The inhabitants of the country, knowing the applicability of that stone, are in the habit of detaching pieces of it by arrow-shots, which pieces, falling into the water, are recovered by diving. From fragments of sufficient size they make calumets, using their knives and awls in manufacturing them. This stone can be worked without difficulty and resists the fire very well."* Leaving aside the incorrect description of the locality and of the character of occurrence, the stone here mentioned corresponds exactly to that of Coteau des Prairies, the latter being, indeed, very often marked with lighter (though not white) spots, which give it a perfectly porphyritic appearance. I have seen many raw pieces of the red pipestone and have some myself, in which this peculiarity is prominently exhibited. The unworked stone is usually of a dull pale red, the heightened color appearing only after the process of polishing.

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* Catlin, North American Indians, London, 1848, Vol II, Letters 54 and 55.

† Shea, Discovery and Exploration of the Mississippi Valley, New York, 1852, p. 35.

Carver, who explored the region of the Upper Mississippi in 1766-'68, mentions the red stone, but does not seem to have visited its place of occurrence, which he marks on his map as the "Country of Peace." He also states distinctly in his work that even individuals belonging to hostile tribes met in peace at the "Red Mountain," where they obtained the stone for their pipes.† This shows that, at his time, the neutrality of the district was still respected. This laudable regulation, it also appears, had not yet become obsolete in the beginning of the present century, for on the map accompanying the work in which Lewis and Clarke describe the territories explored by them in 1804-'6, the locality in question is thus designated: "Here the different Tribes meet in Friendship and collect Stone for Pipes." Yet, about forty years ago, when Catlin visited the Coteau des Prairies, the warlike Sioux or Dakotahs had usurped the exclusive authority over the quarry, not permitting their enemies to provide themselves with stone. Catlin and his English traveling companion encountered at first difficulties on their way to the quarry, a band of those Indians trying to prevent them from going there. "As this red stone," the warriors said, "was a part of their flesh, it would be sacrilegious for white men to touch or take it away; a hole would be made in their flesh and the blood could never be made to stop running."‡ When, subsequently, after Catlin's return from the quarry, an old chief of the Sacs saw some pieces of the red stone in the traveler's possession, he observed: "My friend, when I was young I used to go with our young men to the Mountain of the Red Pipe and dig out pieces for our pipes. We do not go now, and our red pipes, as you see, are but few. The Dakotahs have spilled the blood of the red men on that place and the Great Spirit is offended."§

Mr. Catlin is of opinion that the Indian quarrying operations at Coteau des Prairies reach back into far remote times, basing his view chiefly on the traditions of the Indians, which certainly indicate a comparatively long acquaintance with the locality. It appears, however, hardly admissible to ascribe a *very* high antiquity to the quarry, considering that thus far no pipes or objects of ornament made of the red stone have been discovered in the oldest tumuli of the Mississippi valley, and the results of a recent examination of the Côteau des Prairies by Dr. F. V. Hayden likewise tend to detract much from the supposed antiquity of this aboriginal place of resort. According to Dr. Hayden, the layer of Catlinite, hardly a foot in thickness, rests upon a gray quartzite, and there are about five feet of the same gray quartzite above it, which the Indians had to remove with great labor before the pipestone could be secured. A ditch from four to five feet wide and about five hundred yards in length indicates the extent of work done by the Indians. Only about one-fourth of the pipestone layer, thin as it is, can be used for the manufacture of pipes and other objects, the remainder being too impure, slaty, or fragile. Dr. Hayden describes the place as unpicturesque and deficient in trees. He found no stone implements in the vicinity, nor did he learn that any had ever been found; rusty iron tools, on the other hand, are frequently discovered. According to his view, the quarry belongs to a comparatively recent period.†

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* Du Pratz, Histoire de la Louisiane, Paris, 1758, Vol. I, p. 326. The passage in question is not quite clear. It remains doubtful whether DuPratz, in speaking of the stone resembling porphyry, relates what he has heard himself, or alludes to the journal of M. de Bourgmont, to which he refers on the preceding page. The last-named cavalier undertook, in 1724, an expedition to the country of the Padoucas, or Comanches. The erroneous account may be due to the natives, who purposely misplaced the locality of the quarry.

† Carver, Travels, p. 78.

‡ Catlin, Vol. II, p. 166.

§ Ibid., Vol. II, p. 171.

Nevertheless the fact seems to be well established that the surrounding tribes resorted for many succeeding generations to this locality, and that it formed a neutral ground, which they approached with a kind of superstitious awe. The Indians looked upon the red stone as a particularly valuable gift of the Great Spirit, and Catlin relates from personal observation that they humbly sacrificed tobacco before five huge boulders of granite near the quarry, in order to acquire the privilege, as it were, to take away a few pieces of the stone.† At present the settlements of the whites are advancing toward that interesting spot, which lies now, indeed, within the State of Minnesota, close to its western border, and in a county to which the name "Pipestone" has been given. A communication from Dr. Hayden informs me that the place is still visited by Dakotah Indians, but not very frequently, and without the observance of those ceremonies which formerly appeared indispensable. Not much longer, however, will the red man be seen to make his pilgrimage to the quarry of Coteau des Prairies.

Mr. Catlin has published very good drawings of the red pipes, which are, moreover, familiar to every one who has paid some attention to Indian matters. Some of them bear testimony to the skill and patience of their makers, who, in most cases, probably possess no other implements than the knives and files obtained from the traders. The cylindrical or conical cavities in the bowl and neck of these pipes are drilled with a hard stick and sharp sand and water.‡

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* Hayden, in American Journal of Science and Arts, Vol. XLIII, January, 1867.

† Catlin, Vol. II, p. 166.

‡ Catlin, Vol. I, p. 234.

Not long ago a small Catlinite pipe of unusual shape was sent to me, which had been ploughed up in a maize-field near Centreville, in Southern Illinois (St. Clair County). Such older specimens are even met in the New England States, near the Atlantic coast. The collection of the Smithsonian Institute contains some pipes and ornaments made of Catlinite, which were taken from Indian graves in the State of New York, or obtained from the Iroquois still inhabiting the same State. The raw or worked red pipestone, therefore, constituted an article of barter, which was brought from its original place of occurrence to the present Eastern States of the Union. A passage in Loskiel, who chiefly treats of the Delawares and Iroquois, refers to this trade. In describing the pipes of those Indians, he says: "Some are manufactured from a kind of red stone, which is sometimes brought for sale by Indians who live near the Marble river, on the western side of the Mississippi, where they extract it (*sic*) from a mountain."* This passage, it will be noticed, implies a direct trade-connection of great extent, the distance between the red pipestone quarry and the Northern Atlantic States being equal to twelve or thirteen hundred English miles.

SHELLS.

A substance pleasing to the eye, and easily worked, such as is offered by nature in the shells of marine and fresh-water mollusks, could not fail to attract the attention of men in the earliest times. The love of personal adornment, moreover, already manifests itself in the lowest stages of human development,† and shells being, above other natural productions, particularly fitted to be made into ornaments, it is not surprising that they were employed for that purpose in all parts of the world. The North American tribes made an extensive use of the shells of the sea-coast as well as of those of their rivers, and fossil marine shells were also employed as ornaments. The valves of recent marine mollusks, indeed, must have been widely circulated by barter, considering that they are found, in the shape of ornaments, and sometimes of utensils, in the interior of North America, at great distances from the shores of the sea. The oldest reference to the shell-trade among the aborigines is contained in the remarkable account of the Spaniard Alvar Nuñez Cabeça de Vaca, who accompanied in the year 1527, as treasurer and alguazil mayor, the unfortunate Pamphilo de Narvaez on his expedition for the conquest of Florida The leader and nearly all his followers having perished, Cabeça de Vaca, one of the survivors, wandered with his companions for many years through North America, until he finally succeeded in reaching the settlements of his countrymen near Culiacan, in the present Mexican province of Sinaloa, after having traversed the whole continent from the Floridian peninsula to the Pacific coast. The description of his adventures and sufferings forms one of the most remarkable early works on North America, being, indeed, the first that treats of the interior of the country and of its native population. For the latter reason it is of particular value to the ethnologist, presenting, as it does, the Indians as they were seen by the first white visitors.* While he sojourned among the Charruco Indians, a tribe inhabiting the coast, he carried on the business of a trader, which, as he observes, suited him very well, because it protected him at least from starvation. The excursions undertaken in the pursuit of his trade sometimes extended as far as forty or fifty leagues from the coast into the interior of the district. His wares consisted of pieces and "hearts" of sea-shells (*pedaços de caracoles de la mar y coraçones de ellos*), of shells employed by the Indians as cutting implements, and of a smaller kind that was used as money. These objects of trade he transported to parts distant from the sea, exchanging them there for other articles of which the coast-people were in want, such as hides, a red earth for painting their faces, stones for arrowheads, hard reeds for shafting the latter, and, finally, tufts of deer's hair dyed of a scarlet color, which were worn as head-dresses.† This passage, indeed, is of particular interest in connection with the subject treated in this essay, because it affords not only some insight into the system of Indian trade, but likewise informs us that among the objects of exchange those were conspicuous which served for the gratification of personal vanity. By the "hearts" of sea-shells Cabeça de Vaca understands the spines or *columellæ* of large conchs, which parts were worked by the aborigines into a kind of ornament, of which more will be said hereafter.

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* Loskiel, Mission der evangelischen Brüder unter den Indianern in Nordamerika, Barby, 1789, p. 66.

† It is probable that the barbarous manufacturers of the rude flint tools found, associated with the bones of extinct animals, in the diluvial deposits of Northern France, used small round petrefacts of the chalk (*Coscinopora globularis*, D'Orb.) as beads, by stringing them together, these petrified bodies being provided by nature with holes passing through their middle (Lyell, Antiquity of Man, p. 119). Personal vanity is a prominent feature in the character of the North American Indians. Among the miserable Root-Diggers an old woman has been seen, who "had absolutely nothing on her person but a thread round her neck, from which was pendent a solitary bead." (Irving, Adventures of Captain Bonneville, p. 261.)

Large quantities of shell-ornaments, mostly destined to be strung together or to be worn as pendants, have been found in the sepulchral mounds and other burial-places of the Indian race. In Ohio, according to Messrs. Squier and Davis, beads made of shell and other materials occur even more frequently in the sacrificial mounds than in those of a sepulchral character, a circumstance that may be accounted for by the value attached to these objects by their owners, who deemed them worthy of being offered in their sacrificial rites. The methods employed by the manufacturers doubtless being of the most primitive character, each shell-bead was the result of a certain amount of patient labor, and consequently was esteemed according to the time and art bestowed on its production.

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* The importance of Cabeça de Vaca's work, it seems to me, has been undervalued, perhaps on account of the marvelous cures which he pretends to have performed among the natives. Imbued with the superstitions of his time, he probably believed in his own powers of healing the sick in a supernatural way. When these incredible details are taken away, there remains much in the book that deserves the highest appreciation. According to Arthur Helps, a most careful investigator, his account "bears every mark of truthfulness." See: Helps, The Spanish Conquest in America, Harper's edition, Vol. IV, p. 397.

† Relation et Naufrages d'Alvar Nuñez Cabeça de Vaca, (Ternaux-Compans Collection), Paris, 1837, p. 121, &c. The Spanish original appeared in the year 1555 at Valladolid.

The Indian shell-ornament in its simplest form consisted of entire specimens of small marine univalves, such as species of *Marginella*, *Natica*, and *Oliva*, which, after being conveniently pierced, could be strung together at once without further preparation, and worn as necklaces, armlets, &c. The above-mentioned kinds were met by Squier and Davis in the mounds of Ohio, and in opening the Grave Creek Mound five hundred specimens of Marginella were obtained near one of the skeletons. Some time ago, I received pierced specimens of Marginella, recovered in removing a mound at East St. Louis, in Southern Illinois, which, I believe, contained a great number of them. Small sea-shells appear to be particularly abundant in the Indian graves of the Gulf States. More than a hundred years ago, it was noticed by Carver that sea-shells were much worn by the Indians of the interior parts—he chiefly refers to the Dakotahs on the Upper Mississippi—and reckoned very ornamental. He could not learn how they procured them, but thought they were obtained by traffic with other nations nearer the sea.* Small *fossil* marine shells were sometimes used for the same purpose. In an article published in the Smithsonian Report for 1868, I have stated that a large number of such fossil shells were found, associated with agricultural flint implements, under the surface at East St. Louis, the place already mentioned.† They belonged almost exclusively to the genus *Conovulus* (*Melampus*), and many of them were prepared for stringing by a lateral perforation, as shown in the drawing (on p. 404) representing one of those shells. My knowledge, however, that the Indians used small fossil sea-shells as ornaments is not confined to the case in question, and I presume that many of the small marine shells taken from the mounds, which are considered as belonging to recent species, are, in reality, of fossil origin. Other fossil remains in a worked state, it may be mentioned in this connection, were obtained from the mounds of Ohio, as, for instance, shark's teeth, and others of considerable size, perhaps belonging to a cetaceous animal. The former are notched on both sides, or pierced at the lower end, and may have served, respectively, as amulets, arrowheads, or cutting implements.

Yet, the number of entire sea-shells employed as beads by the natives appears insignificant when compared with the enormous quantity of objects of the same class, which they manufactured from fragments of the valves of marine and fluviatile shells. These wrought beads exhibit various forms and sizes, but, according to my experience, are mostly found in the shape of more or less regular sections of cylinders, pierced through the centre. They are often proportionately thick, but sometimes rather thin, resembling the small bone buttons of commerce. I have shell-beads from different parts of the United States. Most of them are small, not exceeding six or seven millimetres in diameter; my largest specimens, however, have a diameter of no less than twenty-eight millimetres. These latter, which were found, some time ago, with skeletons in the now leveled "Big Mound" at St. Louis, are very flat in proportion to their diameter, and may be called discs rather than beads. They are evidently made from the valves of species of *Unio* of the Mississippi valley. These and other shells, which abound in many rivers of the United States, frequently may have furnished the material for ornaments, especially in districts remote from the sea-coast. The holes of Indian shell-beads generally are drilled from both sides, and therefore mostly of a bi-conical shape.* The colored glass beads and enameled beads often found in Indian graves are, of course, of European origin, the art of making them being unknown to the aborigines, and their occurrence in Indian burial-places, therefore, indicates that the interment took place at a period when an intercourse with the whites already had been established. Of the so-called wampum-beads I shall speak at the close of this section.

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* Carver, Travels, p. 151.

† Their fossil character was first pointed out to me by a competent conchologist, Mr. Thomas Bland, of Brooklyn.

The largest and therefore the most esteemed beads and pendants, however, were made by the Indians from the columellæ, or, as Cabeça de Vaca expresses it, from the "hearts," of large conchs, among which the *Strombus gigas* seems to have been most frequently used. These beads are more or less cylindrical, or globular, and always drilled lengthwise. Some are tapering at both ends, resembling a cigar in shape. I have seen specimens of two and one-half inches in length. The aborigines also made from the columellæ of large marine univalves peculiar pin-shaped articles, consisting of a more or less massive stem, which terminates in a round knob. Professor Wyman mentions, in the Third Annual Report on the Peabody Museum (1870), a specimen of this kind found in Tennessee, which is five inches long, with a head an inch in diameter. In the collection of Colonel Charles C. Jones, of Brooklyn, there are quite similar specimens of this class. Their destination is yet unexplained; they were perhaps attached to the head-dress, or worn as ornaments in some other way. The unwrought columellæ of large sea-shells have been found at considerable distances from the coast, as, for instance, in Ohio and Tennessee.

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* Flat shell-beads are among the oldest antiquities of Europe. Lartet found them in the grotto of Aurignac, which served as a burial-place at a period, when the cave-bear, cave-hyena, mammoth, rhinoceros, &c., still existed. Some small flat beads in my possession, made of *Cardium*, which were obtained from a dolmen in Southern France, cannot be distinguished from similar productions of the North American Indians. Entire sea-shells (mostly *Litorina litorea*), pierced for stringing, occurred in the cave of Cro-Magnon, in the valley of the Vèzére. Pierced valves of fossil sea-shells were found at other stations of the reindeer-period in the same valley, &c.

I have seen some very old Indian shell-ornaments, which were worn suspended from the neck, like medals or gorgets. They are round or oval plates, from two to four inches in diameter, on which various designs, sometimes quite tasteful, are engraved or *cut through*. In some instances their ornamentation consists in regularly disposed perforations.*

Very large sea-shells of the univalve kind, either in their natural state or more or less changed by art, frequently have been found in Indian burial-places and in localities generally, where the traces of Indian occupancy are met. Species of the *Pyrula* and *Cassis* occur most frequently. By the removal of the inner whorls and spines, and other modifications, these shells are sometimes prepared to serve as drinking-vessels and dishes. Professor Wyman speaks in the before-mentioned report of such vessels obtained from Tennessee and Florida, which are made from shells of the *Pyrula perversa*, Lam. One of the vessels measures a foot in length, though the pointed end is wanting. Dr. Troost gives the description and representation of a large, entirely hollowed *Cassis flammea*, Lam., found in Tennessee, which served as the receptacle of a kneeling human figure of clay, to which he attributes the character of an idol.† I saw in the collection of Colonel Jones, of Brooklyn, a *Cassis*, likewise hollowed, which is eight inches and a half long, and has a diameter of seven inches, where its periphery is widest. This specimen is one of two which were found near Clarksville, Habersham County, Georgia, in one of those Indian stone-graves, which are met, sometimes many of them together, in various parts of the United States.‡

In the State of Ohio, where the former inhabitants have left the most conspicuous traces of their occupancy in the shape of numerous earth-works of various descriptions, and sometimes of stupendous extent, these large shells of marine mollusks are of frequent occurrence. Atwater already mentions them in the first volume of the Archæologia Americana, published in 1820. What Squier and Davis observed in regard to sea-shells generally during their investigations in Ohio, I will recapitulate here in a few words. They found in the mounds the smaller shells already specified, namely, *Marginella*, *Oliva*, and *Natica*, as well as entire specimens or fragments of *Cassis* and *Pyrula perversa*, and also the unwrought columellæ of a large species of conch, probably *Strombus gigas*. Entire specimens of the *Pyrula perversa*, they state, frequently have been discovered outside of the mounds, in excavating at different points in the Scioto valley. They found in one of the mounds a large *Cassis*, from which the inner whorls and columella had been removed, to adapt it for use as a vessel. This specimen, eleven inches and a half in length by twenty-four in circumference at the largest part, is now in the Blackmore Museum.[*]

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* "They oftentimes make, of this shell, a sort of gorge, which they wear about their neck in a string; so it hangs on their collar, whereon sometimes is engraven a cross, or some odd sort of figure, which comes next in their fancy. The gorges will sometimes sell for three or four buckskins ready dressed." Lawson, History of Carolina, London, 1714; reprint, Raleigh, 1860, p. 315. For drawings see Schoolcraft, Vol. I, plate 19, figure 3, and plate 25, figures 29 and 30; also, Morgan, League of the Iroquois, p. 389.

† Transactions of the American Ethnological Society, Vol. I, p. 361.

‡ The stone-grave in question contained a skeleton, much decayed, and, besides the two *Cassis*-shells, stone axes and chisels, some perforated objects of stone, &c. The most important piece, however, was a copper axe, which deserves particular mention. This axe is very long, but narrow and thin, and shows on both sides very distinctly the friction produced by having been inserted into the split end of a wooden handle. The objects found in this grave are all in the possession of Colonel Jones, who intends to publish an illustrated description of this find in his forthcoming work on the antiquities of Georgia.

The above-mentioned marine shells, all pertaining to tropical or semi-tropical regions, occur in the United States only on the eastern shore of the peninsula of Florida (perhaps a little higher northward) and on the coast of the Gulf of Mexico. From these localities, therefore, they must have found their way into the interior. Adopting, for example, Cape St. Blas, in the Mexican Gulf, and the centre of Ohio as the limits of shell-trade from south to north (an estimate probably much below reality), we find an intervening distance of nearly eight hundred English miles.

Having repeatedly alluded to large sea-shells prepared by the aborigines to serve as vessels, I will also mention that the Florida Indians, when first seen by Europeans, used such shells as drinking-cups. This we learn from the plates and descriptions contained in the "Brevis Narratio," of Jacques le Moyne de Morgues, in the second volume of DeBry's "Peregrinationes" (Francoforti ad Moenum, 1591). Plate 19 represents Indian widows who have cut off their hair in token of mourning, and scatter it over the graves of their husbands. On the graves are deposited bows and arrows, spears, and the large shells "out of which they drank."[†] The same shells may be seen on Plate 29, where warriors use them as drinking-cups. Plate 40, finally, illustrates the ceremonies which were performed at the death of a chieftain. The tumulus is already heaped up, and around its base arrows are stuck perpendicularly in the ground. The drinking-vessel of the deceased, a large shell, is placed on the top of the mound.[‡] Though the shells are figured quite large in these plates, it is impossible to perceive to what species they belong. Le Moyne drew his scenes of Indian life many years after his return from America, while living in England, and as he executed these delineations from memory, they are doubtless deficient in that minuteness of detail which entitles to safe comparisons and deductions.

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[*] Ancient Monuments, p. 283.

[†] The accompanying text runs thus: "*Ad maritorum sepulcra pervenientes, capillos sub auribus præsecant, illisque per sepulcra sparsis, maritorum arma & conchas ex quibus bibebant ibidem adjiciunt, in strenuorum virorum memoriam.*"

[‡] In the text: "*Defuncto aliquo Rege ejus Provinciæ, magna solennitate sepelitur, & ejus tumulo crater, e quo bibere solebat, imponitur, defixis circa ipsum tumulum multis sagittis.*"

Among some tribes of the interior marine shells seem to have been looked upon with a kind of religious reverence, and indications are not wanting that they played a part in their religious ceremonies. The peculiar sound produced by a sea-shell when approached to the ear necessarily appeared strange and mysterious to them, and the rareness of the shells, together with their elegant forms and beautiful colors, doubtless increased their value in the eyes of the natives. According to Long, the Omahas possessed, about half a century ago, a large shell (already transmitted from generation to generation) to which they paid an almost religious veneration. "A skin lodge or temple," says Long, "is appropriated for its preservation, in which a person constantly resides, charged with the care of it, and appointed its guard. It is placed upon a stand and is never suffered to touch the earth. It is concealed from the sight by several envelops, which are composed of strands of the proper skins, plaited and joined together in the form of a mat. The whole constitutes a parcel of considerable size, from which various articles are suspended, such as tobacco and roots of certain plants. No person dares to open all the coverings of this sacred deposit in order to expose the shell to view. Tradition informs them that curiosity induced three different persons to examine the mysterious shell, who were immediately punished for their profanation by instant and total loss of sight. The last of these offenders, whose name is Ish-ka-tappe, is still living. It was ten years since that he attempted so unveil the sacred shell, but, like his predecessors, he was visited with blindness, which still continues, and is attributed by the Indians, as well as by himself, to his committing of the forbidden act. This shell is taken with the band to all the national hunts, and is then transported on the back of a man. Previously to undertaking a national expedition against an enemy, the sacred shell is consulted as an oracle. For this purpose the magi of the band seat themselves around the great medicine lodge, the lower part of which is then thrown up like curtains and the exterior envelop is carefully removed from the mysterious parcel, that the shell may receive air. A portion of the tobacco, consecrated by being long suspended to the skin-mats or coverings of the shell, is now taken and distributed to the magi, who fill their pipes with it to smoke to the great medicine. During this ceremony an individual occasionally inclines his head forward and listens attentively to catch some sound which he expects to issue from the shell. At length, some one imagines that he hears a sound like that of a forced expiration of air from the lungs, or like the noise made by the report of a gun at a great distance. This is considered as a favorable omen, and the nation prepare for the projected expedition with a confidence of success. But, on the contrary, should no sound be perceived, the issue of the expedition would be considered doubtful."[*] This shell, it cannot be doubted, was of marine origin, though the fact is not stated in the text. The nearest sea-coast from which it could have been obtained is that of the Mexican Gulf, distant about nine hundred miles from the district inhabited by the Omahas.

The white traders used to derive great profit by selling fine sea-shells to the tribes of the interior. Kohl, for instance, learned from Canadian fur-traders that the Ojibways, on Lake Superior, formerly purchased sea-shells from them at considerable prices. "When they (the traders) exhibited a fine large shell, and held it to the ears of the Indians, these latter were astonished, saying they heard the roaring of the ocean in it, and paid for such a marvelous shell furs to the value of thirty or forty dollars, and even more."[†]

Having undertaken to compose this essay for the purpose of bringing together a series of facts relating to the trade among the aborigines of North America, I would be guilty of an omission, if I neglected to mention the wampum-beads, which, besides other uses, represented the *money* among them. The term "wampum" is often applied to shell-beads in general, but should be confined, I think, to a certain class of cylindrical beads, usually one-fourth of an inch long and drilled lengthwise, which were chiefly manufactured from the shells of the common hard-shell clam (*Venus mercenaria*, Lin). This bivalve occurring, as every one knows, in great abundance on the North American coasts, formed an important article of food of the Indians living near the sea, a fact demonstrated by the enormous quantity of castaway clam-shells, which form a considerable part of North American *Kjoekkenmoeddings.* The natives used to string the mollusks and to dry them for consumption during winter. The blue or violet portions of the clam-shells furnished the material for the dark wampum, which was held in much higher estimation than that made of the white part of the shells, or of the spines of certain univales. Even at the present time places are pointed out on the Atlantic sea-board, for example on that of Long Island, where the Indians manufactured wampum, and such localities may be recognized by the accumulations of clam-shells from which the blue portions are broken off.

Wampum-beads formed a favorite material for the manufacture of necklaces, bracelets, and other articles of ornament, and they constituted the strings and belts of wampum, which played such a conspicuous part in Indian history.

Loskiel makes the following statement in reference to wampum: "Before North America was discovered by the Europeans, the Indians mostly made their strings and belts of small pieces of wood, cut to an equal size and dyed white and black. They made some of shells, which they highly esteemed, but they manufactured them very rarely, because this labor required much time for want of the proper tools; and the beads, moreover, were of a rude and clumsy appearance. Soon after their arrival in America, the Europeans began to manufacture wampum from shells, very neatly and in abundance, exchanging it to the Indians for other commodities, thus carrying on a very profitable trade. The Indians now abandoned their wooden belts and strings, and substituted those of shell. The latter, of course, gradually declined in value, but, nevertheless, were and still are much prized."[*]

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[*] Long, Expedition from Pittsburgh to the Rocky Mountains, performed in the years 1819 and 1820, London, 1823, Vol. II, p. 47, &c.

[†] Kohl, Kitschi-Gami, Vol. I, p. 186.

I have little faith in Loskiel's statement that the Indians chiefly used wood for the above-mentioned purpose, before they had intercourse with the whites. Loskiel never visited America; he composed, as he observes in the preface, his work from the journals and reports of Protestant missionaries, and probably was totally unacquainted with the early writings relating to North America, in which wampum is mentioned. Roger Williams, for example, who emigrated to North America in 1631, is quite explicit on that point. He states that the Indians manufactured white and dark wampum-beads, and that six of the former and three of the latter were equivalent to an English penny. Yet it appears that even at his time the colonists imitated the wampum, and used it in their trade with the natives. "The Indians," he says, "bring downe all their sorts of Furs, which they take in the countrey, both to the Indians and to the English for this Indian Money: this Money the English, French, and Dutch, trade to the Indians, six hundred miles in severall parts (North and South from New-England) for their Furres, and whatsoever they stand in need of from them: as Corne, Venison, &c."[†] Similar statements are contained in the writings and records of various persons who lived in North America contemporaneously with the liberal-minded founder of Rhode Island. Even in the intercourse of the English colonists among themselves, wampum served at certain periods instead of the common currency, and the courts of New England issued from time to time regulations for fixing the money-value of the wampum. In transactions of some importance it was measured by the fathom, the dark or blue kind generally being double the value of the white.[‡] According to Roger Williams, the Indians of New England—he chiefly refers to the Narragansetts—denoted by the term *wompam* (which signifies *white*) the white beads, while they called the dark kind *suckauhock* (from *sácki, black*).[§] The great value attached to wampum as an ornament is well illustrated by the following passage from the same author: "They hang these strings of money about their necks and wrists; as also upon the necks and wrists of their wives and children. *Múchequoce*, a Girdle; which they make curiously of one, two, three, foure, and five inches thicknesse and more, of this money which (sometimes to the value of ten pounds and more) they weare about their middle and as a scarfe about their shoulders and breasts. Yea, the Princes make rich Caps and Aprons (or small breeches) of these Beads thus curiously strung into many formes and figures: their blacke and white finely mixt together."*

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[*] Loskiel, Mission der evangelischen Brüder, &c., p. 34.

[†] Roger Williams, A Key, &c., p. 128.

[‡] Interesting details concerning wampum are given by Mr. Stevens in "Flint Chips," London, 1870, pp. 454–64.

[§] Roger Williams, l. c. p. 130. In another place (p. 154) he gives the word *wómpi* for *white*. *Wampumpeage, peak, seawant, roanok,* were othe names to signify wampum.

The wampum-belts, so often mentioned in connection with the history of the eastern tribes, consisted of broad straps of leather, upon which white and blue wampum-beads were sewed in rows, being so arranged that by the contrast of the light and dark colors certain figures were produced. The Indians, it is well known, exchanged these belts at the conclusion of peace, and on other solemn occasions, in order to ratify the transaction and to perpetuate the remembrance of the event. When sharp admonitions or threatening demonstrations were deemed necessary, the wampum-belts likewise played a part, and they were even sent as challenges of war. In these various cases the arrangement of the colors and figures of the belts corresponded to the object in view: on peaceable occasions the white color predominated; if the complications were of a serious character, the dark prevailed; and in the case of a declaration of war, it is stated, the belt was entirely of a somber hue, and, moreover, covered with red paint, while there appeared in the middle the figure of a hatchet executed in white. The old accounts, however, are not quite accordant concerning these details, probably because the different Atlantic tribes followed in this particular their own taste rather than a general rule. At any rate, however, the wampum-belts were considered as objects of importance, being, as has been stated, the tokens by which the memory of remarkable events was transmitted to posterity. They were employed somewhat in the manner of the Peruvian *quipu*, which they also resembled in that particular, that their meaning could not be conveyed without oral comment. At certain times the belts were exhibited, and their relations to former occurrences explained. This was done by the aged and experienced of the tribe, in the presence of young men, who made themselves thoroughly acquainted with the shape, size, and marks of the belts as well as with the events they were destined to commemorate, in order to be able to transmit these details to others at a future time. Thus the wampum-belts represented the archives of polished nations. Among the Iroquois tribes, who formed the celebrated "league," there was a special "keeper of the wampum," whose duty it was to preserve the belts and to interpret their meaning, when required. This office, which bore some resemblance to that of the quipu-decipherer (*quipu-camayoc*) of the Peruvians, was intrusted to a sachem of the Onondagas.†

In March, 1864, a delegation of Iroquois of the State of New York passed through New York City on their way to Washington, where they intended to negotiate with the Government concerning former treaties relative to their lands. They had brought with them their old wampum-belts, as documents to prove the justness of their claims. One of these belts, if I am not mistaken, had been given them by General Washington on some important occasion; for even the whites of that period were under the necessity of conforming to the established rule in their transactions with the natives. The New York Historical Society honored these delegates with a public reception, which ceremony took place in the large hall of the Society. The president delivered the speech of welcome, which an old chief, unable to express himself in English, answered in the Seneca dialect. A younger chief, Dr. Peter Wilson, called by the people of his tribe *De-jih-non-da-weh-hoh*, or the "Pacificator," served as interpreter, being well versed in both languages. He afterward exhibited the belts, and explained their significance. They were, as far as I can recollect, about two feet long and of a hand's breadth. The ground consisted of white beads, while blue ones formed the figures or marks. The latter resembled ornamental designs, and I could not discover in them the form of any known object. I compared them at the time to somewhat roughly executed embroideries of simple patterns. I asked the "Pacificator" whether these belts were the work of Indians or of whites; but he was unable to give me any definite information on that point.[*]

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* Ibid., p. 131.

† Morgan, League of the Iroquois, p. 121.

I possess a number of white and blue wampum-beads from an Indian grave, opened in 1861, near Charlestown, in the State of Rhode Island. The late Dr. Usher Parsons, of Providence, Rhode Island, to whom I am indebted for these beads, has described the grave,[†] and thinks it enclosed the remains of a daughter of Ninigret, Sachem of the Niantic or Nahantic tribe of Indians. The interment is supposed to have taken place about the year 1660. These beads are regularly worked cylinders, drilled lengthwise, and from five to nine millimetres in length, by four or five in diameter. Of course, it cannot now be decided whether Indians or whites were their manufacturers. The grave contained many other objects, but almost without exception derived from the colonists of that period. I may also state, in this place, that thus far I have not found in the oldest English works on North America a perfectly satisfactory account of the method originally employed by the Indians in the manufacture, and especially in the drilling, of the wampum-beads.[‡]

Among the tribes of the northwestern coast of North America, from the northern border of California far upward to the north, the shells of the *Dentalium* represented, until within the latest time, the wampum of the Atlantic region, being used, like the latter, both as ornament and money. These shells, which abound in certain places of the Pacific coast, may be likened to small, tapering, and somewhat curved tubes. Being open at both ends, they can be strung without further preparation. As my essay relates only to that portion of North America which lies east of the Rocky Mountains, I probably would not have mentioned the use of Dentalium-shells, were it not for the fact that they have been found in the interior of the country, far from the Pacific coast, as personal ornament of existing tribes, and even in the ancient mounds of Ohio.* The latter fact, indeed, is of great interest in its bearing on the extent of former aboriginal trade-relations, the distance from the Pacific to the State of Ohio being almost equal to the whole breadth of the North American continent.†

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[*] This is the same chief who delivered, in 1847, before the New York Historical Society, a powerful speech, quoted by Morgan, (League of the Iroquois, p. 440). The chief's name was then *Wä-o-wo-wă-nó-onk*.

[†] New York Historical Magazine, February, 1863.

[‡] "Before ever they had awle blades from Europe, they made shift to bore this their shell money, with stones, and to fell their trees with stone set in a wooden staff, and used wooden howes; which some old and poore women (fearfull to leave the old tradition) use to this day."—*Roger Williams*, *Key*, p. 130.

PEARLS.

Perforated pearls, destined to serve as beads, often form a part of the contents of ancient North American mounds. Squier and Davis found them on the hearths of five distinct groups of mounds in Ohio, and sometimes in such abundance that they could be gathered by the hundred. Most of them had greatly suffered by the action of fire, being in many cases so calcined that they crumbled when handled; yet, several hundred were found sufficiently well preserved to permit of their being strung. The pearls in question are generally of irregular form, mostly pear-shaped, though perfectly round ones are also among them. The smaller specimens measure about one-fourth of an inch in diameter, but the largest has a diameter of no less than three-fourths of an inch.‡ According to Squier and Davis, pearl-bearing shells occur in the rivers of the region whose antiquities they describe, but not in such abundance that they could have furnished the amount discovered in the tumuli; and the pearls of these fluviatile shells, moreover, are said to be far inferior in size to those recovered from the altars. The latter, they think, were derived from the Atlantic coast and from that of the Mexican Gulf. It is a fact that the Indians, who inhabited the present Southern States of the Union, made an extensive use of pearls for ornamental purposes. This is attested by the earliest accounts, and more especially by the chroniclers of De Soto's expedition (the anonymous Portuguese gentleman and Garcilasso de la Vega), who speak of almost fabulous quantities of pearls, which that daring leader and his followers saw among the Indians of the parts traversed by them. Pearls, however, belonged to the things most desired by the Spaniards, and the accounts relating to them, perhaps, may be somewhat exaggerated. The following passage from Garcilasso de la Vega is of particular interest:

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* Stevens, Flint Chips, p. 468.

† Since writing the above, I learned, by consulting Woodward's work on conchology, that the *Dentalium* is also found in the West Indies. If it should likewise occur on the southern coasts of the United States, there is at least a possibility that the specimens found in Ohio may have been obtained from the last-named region.

‡ Ancient Monuments, p. 232.

"While De Soto sojourned in the province of Ichiaha,* the cacique visited him one day, and gave him a string of pearls about two fathoms (*deux brasses*) long. This present might have been considered a valuable one, if the pearls had not been pierced; for they were all of equal size and as large as hazle-nuts.† Soto acknowledged this favor by presenting the Indian with some pieces of velvet and cloth, which were highly appreciated by the latter. He then asked him concerning the pearl-fishing, upon which he replied that this was done in his province. A great number of pearls were stored in the temple of the town of Ichiaha, where his ancestors were buried, and he might take as many of them as he pleased. The general expressed his obligation, but observed that he would take away nothing from the temple, and that he had accepted his present only to please him. He wished to learn, however, in what manner the pearls were extracted from the shells. The cacique replied that he would send out people to fish for pearls all night, and on the following day at eight o'clock (*sic*) his wish should be gratified. He ordered at once four boats to be dispatched for pearl-fishing, which should be back in the morning. In the mean time much wood was burned on the bank, producing a large quantity of glowing coals. When the boats had returned, the shells were placed on the hot coals, and they opened in consequence of the heat. In the very first, ten or twelve pearls of the size of a pea were found, and handed to the cacique and the general, who were present. They thought them very fine, though the fire had partly deprived them of their lustre. When the general had satisfied his curiosity, he retired to take his dinner. While thus engaged, a soldier came in, who told him that in eating some of the oysters caught by the Indians, a very fine and brilliant pearl had got between his teeth, and he begged him to accept it as a present for the governess of Cuba.‡ Soto very civilly refused the present, but assured the soldier that he was just as much obliged to him as though he had accepted his gift: he would try to reward him one day for his kindness and for the regard he was showing to his wife. He advised him to keep his (intended) present, and to buy horses for it at Havana. The Spaniards, who were with the general at that moment, examined the pearl of this soldier, and some, who considered themselves as experts in the matter of jewelry, thought it was worth four hundred ducats. It had retained its original lustre, not having been extracted by means of fire."*

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* The province and town of Iciaha, or Ichiaha, have been located in that part of Northern Georgia where the Oostanaula and Etowah rivers unite, and form the Coosa river. (See Theodore Irving's "Conquest of Florida," second edition, p. 242; also McCulloh's "Researches," p. 525.)

† The Indians used to pierce them with a heated copper wire, a process by which they were spoiled.

‡ Doña Isabel de Bobadilla, De Soto's wife.

It is evident, therefore, that the Indians obtained their pearls, in part at least, from their river-muscles, many of which are known to be margaritiferous.† These mollusks undoubtedly were used as food by the aborigines, who ate alligators, snakes, and other animals less tempting than the contents of fluviatile shells. Indeed, I learned from Dr. Brinton, who was attached to the Army of the Cumberland during the late civil war, that muscles of the Tennessee river were occasionally eaten "as a change" by the soldiers of that corps, and pronounced no bad article of diet. Shells of the *Unio* are sometimes found in Indian graves, where they had been deposited with the dead, to serve as food during the journey to the land of spirits. In many parts of the North American inland heaps of fresh-water shells are seen, indicating the places where the natives feasted upon the mollusks. Atwater has drawn attention to such accumulations on the banks of the Muskingum, in Ohio.‡ Heaps of muscle-shells may be seen in Alabama, along the rivers wherever Indians used to live. Thousands of the shells lie banked up, some deep in the ground.§ Dr. Brinton saw on the Tennessee river and its tributaries numerous shell-heaps, consisting almost exclusively of the *Unio virginianus* (Lamarck?). In all instances he found the shell-heaps close to the water-courses, on the rich alluvial bottom-lands. "The mollusks," he says, "had evidently been opened by placing them on a fire. The Tennessee muscle is magaritiferous, and there is no doubt but that it was from this species that the early tribes obtained the hoards of pearls which the historians of De Soto's exploration estimated by bushels, and which were so much prized as ornaments. It is still a profitable employment, the jewelers buying them at prices varying from one to fifty dollars."‖ *Kjoekkenmoeddings* on the St. John's river, in Florida, consisting of river-shells, were examined by Professor Wyman, and described by him; he saw similar accumulations on the banks of the Concord river in Massachusetts, and was informed by eye-witnesses that they are numerous in California.¶ On Stalling's Island, in the Savannah river, more than two hundred miles above its mouth, there stands a mound of elliptical shape, chiefly composed of the muscles, clams, and snail-shells of the river. This tumulus, which is about three hundred feet long, one hundred and twenty feet wide, and, perhaps, over twenty feet high, was found to contain a large number of skeletons. "Several pits have been opened in the northeastern end. At the depth of twelve feet the amount of shells was undiminished. They appear to have been distributed in layers of eight or ten inches in thickness, with intervening strata of sand. An examination into the contents of the mound proves conclusively that it must have been used only for burial purposes; that it is, in fact, a huge necropolis. It could not have been the work of a year, or of a generation. Stratum upon stratum has been heaped, each covering the dead of its age, until by degrees, and with the lapse of time, it grew into its present surprising dimensions."*

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* Garcilasso de la Vega, Conquête de la Floride, Vol. II, p. 296.

† As Mr. Isaac Lea, of Philadelphia, informs me, pearls are found in various species of the *Unionidæ*, more frequently in *Unio complanatus*, *Margaritana margaritifera*, and *Anodonta fluviatilis*. But they occur occasionally in all the species of this family. Very large and valuable pearls have been found in New Jersey.

‡ Archæologia Americana, Vol. i, p. 226.

§ Pickett, History of Alabama, Charleston, 1851, Vol. I p. 12.

‖ Brinton, Artificial Shell-Deposits in the United States, Smithsonian Report for 1866, p. 357.

¶ Wyman, Fresh-Water Shell-Heaps of the St. John's River, East Florida, Salem, Massachusetts, 1868, p. 6.

It is probable that the natives of North America obtained pearls, both from fluviatile and marine shells, and further that they caught the bivalves, not solely on account of the pearls they inclosed, but for using them as food. The pearls themselves, in all likelihood, were looked upon as additional, highly valued gifts of nature.

DIVISION OF LABOR.

Among the later Indians, at least those who lived east of the Rocky Mountains, nearly all work was performed by women. When, during times of peace, the master of a lodge had supplied his family with the game necessary for its support, he thought to be relieved of further duties, and abandoned himself either to indolence or to his favorite pastimes, such as games of hazard, and exercises calculated to impart strength and agility to the body. He manufactured, however, his arms and kept them in repair, and also condescended to work, when a larger object, a canoe for instance, was to be made, or a dwelling to be constructed. Far more varied, on the other hand, were the duties imposed upon women. Not only had they to procure water and fire-wood, to prepare the meals, to collect the fruits serving as winter-provisions, to make moccasins and other articles of dress, but it was also incumbent upon them to perform many other labors, which, from their nature, would seem to be more suited for men. Thus, the fields were cultivated by women;† they dressed the skins to fit them for garments and other purposes; the manufacture of pottery was a branch of female industry; they did the principal work in the erection of the huts or tents (of skins, mats or bark), and their assistance was even required when canoes, especially those of bark, were made. During the march they carried heavy loads, and on the water they handled the paddle as skilfully as the men. If to all those tasks and toils the bringing up of children is added, the lot of the Indian woman appears by no means an enviable one, though she bore her burden patiently, not being accustomed to a different manner of existence. She was, indeed, hardly more than the servant of her lord and master, who frequently lived in a state of polygamy merely for commanding more assistance in his domestic affairs.

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* Jones (Charles C.), Monumental Remains of Georgia, Savannah, 1861, p. 14.

† Also, to some extent, by enslaved prisoners of war.

Such were the occupations of Indian men and women *in general.* Nevertheless, there are indications that the germs of handicrafts already existed among the North American tribes, or, to speak more distinctly, that certain individuals of the male sex, who were, by natural inclination or practice, particularly qualified for a distinct kind of manual labor, devoted themselves principally or entirely to this labor. I refer, of course, to the period anteceding the occupation of the country by Europeans—that period about which so little is known, that a careful examination of the still existing earth-works, and of the minor products of industry left by the former inhabitants, affords the principal guidance in the attempt to determine their mode of existence. The earliest writings on North America are exceedingly deficient in those details which are of interest to the archæologist, and form, as it were, his points of departure; and it becomes therefore necessary to adopt here, in the pursuit of archæological investigation, the same system of careful inquiry and deduction that has been so successfully employed in Europe. The only difference is, that in the latter part of the world "prehistoric times" reach back thousands of years into the remotest antiquity, while in America a comparatively recent period must be drawn within the precinct of antiquarian research.

Any one who examines a collection of North American chipped flint implements will notice quite rude and clumsy specimens, but also, alongside of these, others of great regularity and exquisite finish, which could only have been fashioned by practised workers in flint. This applies particularly to the points of arrows and lances, some of which are so sharp and pointed that they, when properly shafted, almost would be as effectual as iron ones. In fact, the oldest Spanish writings contain marvelous accounts of the penetrating force of the flint-pointed arrows used by the Indians of Florida in their encounters with the whites. Not every warrior, it may be presumed, was able to make stone-points, especially those of a superior kind, this labor requiring a skill that could only be attained by long practice. There were doubtless certain persons among the various tribes who practised arrow-making as a profession, and disposed of their manufactures by way of exchange. In reference to this subject Mr. Schoolcraft observes as follows: "A hunter, or warrior, it is true, expected to make his own arms or implements, yet the manufacture of flint and hornstone into darts and spears and arrowheads demanded too much skill and mechanical dexterity for the generality of the Indians to succeed in. According to the Ojibway tradition, before the introduction of fire-arms, there was a class of men among the northern tribes who were called *makers of arrowheads.* They selected proper stones, and devoted themselves to this art, taking in exchange for their manufactures, the skins and flesh of animals." According to Colonel Jones, the tradition has been preserved in Georgia "that among the Indians who inhabited the mountains, there was a certain number or class who devoted their time and attention to the manufacture of these darts. That as soon as they had prepared a general supply, they left their mountain homes and visited the sea-board and intermediate localities, exchanging their spear and arrowheads for other articles not to be readily obtained in the region where they inhabited. The further fact is stated that these persons never mingled in the excitements of war; that to them a free passport was at all times granted, even among tribes actually at variance with that of which they were members; that their avocation was esteemed honorable, and they themselves treated with universal hospitality. If such was the case, it was surely a remarkable and interesting recognition of the claims of the manufacturer by an untutored race."*

In a former section I have mentioned a Californian Indian of the Shasta tribe, who was seen making arrowheads of obsidian by Mr. Caleb Lyon. "The Indian," he says, "seated himself on the floor, and, placing a stone anvil upon his knee, which was of compact talcose slate, with one blow of his agate chisel he separated the obsidian pebble into two parts, then giving another blow to the fractured side he split off a slab a fourth of an inch in thickness. Holding the piece against the anvil with the thumb and finger of his left hand, he commenced a series of continuous blows, every one of which chipped off fragments of the brittle substance. It gradually assumed the required shape. After finishing the base of the arrowhead (the whole being only a little over an inch in length) he began striking gentler blows, every one of which I expected would break it into pieces. Yet such was their adroit application, his skill and dexterity, that in little over an hour he produced a perfect obsidian arrowhead. *Among them arrow-making is a distinct trade or profession, which many attempt, but in which few attain excellence.*" †

Another method of arrow-making practised by the Californian tribes is mentioned by Mr. Edward E. Chever in an article published in the "American Naturalist," May, 1870. He has figured the implement used in the process (p. 139). "The arrow-head," he says, "is held in the left hand while the nick in the side of the tool is used as a nipper to chip off small fragments."

Mr. Catlin gives an interesting and full account of the manufacture of arrowheads among the Apaches and other tribes living west of or in the Rocky Mountains. The following extract contains his principal statements: "Erratic boulders of flint are collected (and sometimes brought an immense distance) and broken with a sort of sledge-hammer made of a rounded pebble of hornstone, set in a twisted withe, holding the stone and forming a handle. The flint, at the indiscriminate blows of the sledge, is broken into a hundred pieces. The master-workman, seated on the ground, lays one of these flakes on the palm of his left hand, holding it firmly down with two or more fingers of the same hand, and with his right hand, between the thumb and two forefingers places his chisel or punch* on the point that is to be broken off; and a co-operator (a striker) sitting in front of him, with a mallet of very hard wood, strikes the chisel on the upper end, flaking the flint off on the under side, below each projecting point that is struck. The flint is then turned and chipped in the same manner from the opposite side; and so turned and chipped until the required shape and dimensions are obtained, all fractures being made on the palm of the hand, whose yielding elasticity enables the chip to come off without breaking the body of the flint, which would be the case if they were broken on a hard substance. This operation is very curious, both the holder and the striker singing, and the strokes of the mallet given exactly in time with the music, and with a sharp and *rebounding* blow, in which, the Indians tell us, is the great *medicine* (or mystery) of the operation. Every tribe has its *factory* in which these arrowheads are made, and in those *only certain adepts are able or allowed to make them for the use of the tribe.*"†

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* Jones (Charles C.), Indian Remains in Southern Georgia. Address delivered before the Georgia Historical Society, Savannah, 1859, p. 19.

† Bulletin of the American Ethnological Society, New York, 1861, Vol. I, p. 39.

Thus tradition as well as modern experience justify the belief that the manufacture of arrow and spearheads was formerly carried on as a craft by certain individuals of the North American tribes, and Longfellow's "Ancient Arrow-maker," therefore, is not a mythical person, but the ideal type of a class of men whose art flourished in by-gone times.

The skilfully executed agricultural flint implements of East St. Louis, described by me in the Smithsonian Report for 1868, have altogether the appearance as if *one* hand had fashioned them. Is it not probable that they formed the magazine of an aboriginal artisan, who devoted his time chiefly to the manufacture of such tools? The making of wampum and of shell-beads in general may have formed a trade among the tribes inhabiting the sea-board; for this labor required much time and promised success only to those who, by long practice, had attained skill in the operation. The supposition gains some ground by an observation of Roger Williams, who states that "most on the Sea side make Money and Store up shells in Summer against Winter whereof to make their money." He further observes on the same page: "They have some who follow onely making of Bowes, some Arrowes, some Dishes (and the women make all their Earthen Vessells,) some follow fishing, some hunting."‡

The most remarkable productions of ancient aboriginal industry are the carved stone pipes of peculiar shape exhumed by Messrs. Squier and Davis from the mounds of Ohio, and minutely described and figured by them in the "Ancient Monuments of the Mississippi Valley.§"

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* Six or seven inches in length, and made of an incisor of the sperm-whale, often stranded on the coast of the Pacific.

† Catlin, Last Rambles amongst the Indians, New York, 1867, p. 187, &c.

‡ Roger Williams, A Key, &c., p. 133.

§ Chapter XV, Sculptures from the Mounds, pp. 242–278.

Four miles north of Chillicothe, Ohio, there lies, close to the Scioto river, an embankment of earth somewhat in the shape of a square with strongly rounded angles, and enclosing an area of thirteen acres, over which twenty-three mounds are scattered without much regularity. This work has been called "Mound City," from the great number of mounds within its walls. In digging into the mounds, Squier and Davis discovered hearths in many of them, which furnished a great number of aboriginal relics. From one of the hearths nearly two hundred of those peculiar stone pipes were taken, many of them, unfortunately, cracked by the action of the fire, and otherwise damaged. The occurrence of these "mound-pipes," however, was not confined to the mound in question, similar ones having occasionally been found elsewhere. In the more elaborate pipes from Mound City, the bowl is sometimes formed in imitation of the human head, but generally of the body of an animal, and in the latter cases the peculiar characteristics of the species which have served as models are frequently expressed with surprising fidelity. The following mammals have been recognized: the beaver, otter, elk, bear, wolf, dog, panther, wild cat, raccoon, opossum, squirrel, and sea-cow (Manati, Lamantin, *Trichecus manatus*, Lin.). Of the last-named animal, no less than seven representations were found, a circumstance deserving particular notice, because this inhabitant of tropical waters is not met in the higher latitudes of North America, but only on the coast of Florida, which is many hundred miles distant from Ohio. The Florida Indians called this animal the "big beaver," and hunted it on account of its flesh and bones.* Most frequent are carvings of birds, among which the eagle, hawk, falcon, turkey-buzzard, heron, several species of owls, the raven, swallow, paroquet, duck, and other land and water-birds, have been recognized. One of the specimens is supposed to represent the toucan, a tropical bird not inhabiting the United States. Worthy of particular mention as a well-executed sculpture is a species of eagle or hawk in the attitude of tearing a smaller bird held in its claws; and so is that of the tufted heron feeding on a fish. The amphibious animals, likewise, have their representatives in the snake, toad, frog, turtle, and alligator. One specimen shows a snake that winds itself around the bowl of the pipe. The toads, in particular, are very faithful imitations of nature. Indeed, it is said in the "Ancient Monuments" that, if placed in the grass before an unsuspecting observer, they would probably be mistaken for the natural objects; and this statement is in no way exaggerated, as every one will admit who has seen the specimens in question. The bird-figure supposed to represent the toucan, I think, is not of sufficient distinctness to identify the original that was before the artist's mind; it would not be safe, therefore, to make this specimen the subject of far-reaching speculations. For the rest, the imitated animals belong, without exception, to the North American fauna; and there is, moreover, the greatest probability that the sculptures in question were made in or near the present State of Ohio, where, in corroboration of the last supposition, a few unfinished specimens have occurred among the complete articles. The discovery of the manati-figures, however, is in so far of interest as it indicates a communication between the ancient inhabitants of Ohio and those of the Floridian coast-region.

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* Bartram, Travels, Dublin, 1793, p. 229.

It was formerly believed most of these pipes were composed of a kind of porphyry; but since their transfer to the Blackmore Museum, they were carefully examined and partly analysed by Professor A. H. Church, who found them to consist of softer materials.* Nevertheless, they constitute the most remarkable class of Indian products of art thus far discovered, for some of them are so skilfully executed that a modern artist, notwithstanding his far superior instruments, would find no little difficulty in reproducing them. The manufacture of stone pipes, necessarily a painful and tedious labor, therefore may have formed a branch of aboriginal industry, and the skilful pipe-carver probably occupied among the former Indians a rank equal to that of the experienced sculptor in our time. Even among modern Indians pipe-makers sometimes have been met. Thus, Dr. Wilson mentions an old Ojibway Indian, whose name is *Pabahmesad*, or the "Flier," but who, from his skill in making pipes, is more commonly known as *Pwahguneka*—"he makes pipes."† Kohl, also, speaks of an Ojibway pipe-maker whom he met on Lake Superior. "There are persons among them," he says, "who possess particular skill in the carving of pipes, and make it their profession, or at least the means of gaining in part their livelihood. I made the acquaintance of such a *faiseur de calumet*, and visited him occasionally. He inlaid his pipes very tastefully with figures of stars and flowers of black and white stones. But his work proceeded very slowly, and he sold his pipes at high prices, from four to five dollars apiece. Yet the Indians sometimes pay much higher prices." ‡

In addition to the articles thus far enumerated, others may have been manufactured more or less extensively by way of trade; but, in default of corroborating data, we must rest satisfied with the supposition that such was the case. European archæologists, in estimating the conditions of prehistoric races of the Old World, have derived much aid from inquiries into the modes of life among still-existing primitive populations of foreign parts. The same system may be applied in antiquarian researches relative to North America, where the customs and manners of the yet lingering aboriginal population can be brought into requisition for elucidating the past. Thus, some statements made by Mr. James G. Swan, in a recent work on the Makah Indians of Cape Flattery, (published by the Smithsonian Institute,) are of great interest in connection with the object treated in this article. "The manufacture of implements," he says, "is practised by all; some, however, producing neater articles, are more employed in this way. The manufacture of whaling implements, particularly the staff of the harpoon and the harpoon-head, is confined to individuals who dispose of them to the others. This is also the case with rope-making; although all understand the process, some are peculiarly expert, and generally do the most of the work. Canoe-making is another branch that is confined to certain persons who have more skill than others in forming the model and in finishing the work. Although they do not seem to have regular trades in these manufactures, yet the most expert principally confine themselves to certain branches. Some are quite skilful in working iron and copper, others in carving or in painting, while others again are more expert in catching fish or killing whales."*

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* Church, in "Flint Chips," p. 414.

† Wilson, Prehistoric Man, Lond., 1862, Vol. II, p. 15.

‡ Kohl, Kitschi-Gami, Vol. II, p. 82.

It is true, the conditions of existence of a northern tribe bordering on the Pacific coast cannot serve as a standard for the populations formerly inhabiting the valleys of the Mississippi and Ohio, or the Atlantic sea-board; yet, that the latter were led by similar motives, in regard to the division of labor, seems to be confirmed by the observations and extracts given in this sketch.

CONCLUSION.

In the preceding series of articles I have almost exclusively referred to *manufactures*, and among these, of course, only to such as could, from their nature, resist the destroying influence of time. Yet, it cannot be doubted that articles consisting of less durable materials, for instance, dressed skins, basket-work, mats, wooden ware, &c., formed objects of traffic. The most extensive exchange, perhaps, was carried on in provisions that could be preserved, such as dried or *buccaned* meat, maize, maple-sugar, and other animal or vegetable substances. Those who were abundantly provided with one or the other article of food bartered it to their less favored neighbors, who, in return, paid them in superfluous products or in manufactures of their own. Concerning the ways of communication, the North American continent afforded, by its many navigable waters, rivers as well as lakes, perhaps greater facilities for a primitive commerce than any other part of the earth, and the canoe was the means of conveyance for carrying on this commerce.

The learned Jesuit, Lafitau, has given some account of Indian trade as it was in the beginning of the eighteenth century, at which period he lived, as a missionary, in North America. "The savage nations," he says, "always trade among each other. Their commerce is, like that of the ancients, a simple exchange of wares against wares. They all have something particular which the others have not, and the traffic makes these things circulate among them. Their wares are grain, porcelain (wampum), furs, robes, tobacco, mats, canoes, work made of moose or buffalo hair and of porcupine quills, cotton-beds, domestic utensils—in a word, all sorts of necessaries of life required by them."* A passage from Lawson, a contemporary of Lafitau, may also be inserted with propriety in this place. Speaking of the natives of Carolina, he says: "The women make baskets and mats to lie upon, and those that are not extraordinary hunters make bowls, dishes, and spoons of gum-wood and the tulip-tree; others, where they find a vein of white clay fit for their purpose, make tobacco-pipes, all which are often transported to other Indians that, perhaps, have greater plenty of deer and other game, &c."†

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*Swan, The Indians of Cape Flattery, at the Entrance to the Strait of Fuca, Washington Territory, Washington, 1870, p. 48.

The arrival of the whites produced a thorough change in Indian life, wherever a contact between the two races took place. The age of stone and that of iron met, almost without an intervening link, for the so-called North American "copper period" was but of little practical significance. Simultaneously with the settlement of the eastern parts of North America by the whites, there arose a traffic between these and the Indians in their neighborhood, which provided the latter with implements and utensils so far superior to their own, that they soon ceased to manufacture and use them. The keen-edged steel axe superseded the clumsy and far less serviceable stone tomahawk; the European knife did away with the cutting implement of flint; and those of the natives who could not obtain fire-arms at least headed their arrows with points of iron or brass. The potter's art was neglected, solid and durable vessels of metal supplying the place of the fragile aboriginal fabrics of clay. Instead of procuring fire by turning a wooden stick, fitting in a small cavity of another piece of wood, rapidly between their hands until ignition was effected, the natives now resorted to the far preferable method of striking fire with steel and flint. Their dress, too, underwent changes, pliant woolen and cotton textures being employed to a certain extent instead of dressed skins. Formerly, when the Indians wished to make one of their more durable canoes or a large mortar for pounding maize, they had first to fell a suitable tree, a task which, on account of the insufficiency of their tools, required much labor and time. Being unable to cut down a tree with their stone axes, they resorted to fire, burning the tree around its foot and removing the charred portion with their stone implements. This was continued until the tree fell. Then they marked the length to be given to the object, and resumed at the proper place the process of burning and removing. In a similar manner the hollowing of the tree was effected. But now a few strokes of the European axe did the same work which formerly, perhaps, required days; and to a race as indolent and averse to labor as the Indians, the effect of that simple tool must have appeared almost miraculous.

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* Lafitau, Mœurs des Sauvages Amériquains, Paris, 1724, Vol. II, p. 332.

† Lawson, History of Carolina, London, 1714; reprint, Raleigh, 1860, p. 336.

Greater, however, than these and many other advantages were the evils which the contact with the whites brought upon them; and in succumbing to the overwhelming power of the Caucasians, they shared the fate of every inferior race that takes up the contest with one occupying a higher rank in the family of men.

NORTH AMERICAN STONE IMPLEMENTS.

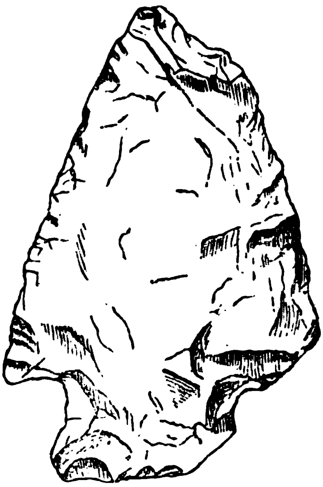
BY CHARLES RAU.

The division of the European stone age into a period of chipped stone, and a succeeding one of ground or polished stone, or, into the palaeolithic and neolithic periods, seems to be fully borne out by facts, and is likely to remain an uncontroverted basis for future investigation in Europe. In North America chipped as well as ground implements are abundant; yet they occur promiscuously, and thus far cannot be referred respectively to certain epochs in the development of the aborigines of the country. Archæological investigation in North America, however, is but of recent date, and a careful examination of our caves and drift-beds possibly may lead to results similar to those obtained in Europe. When in the latter part of the world man lived contemporaneously with the now extinct large pachydermatous and carnivorous animals, he used unground flint tools of rude workmanship, which were superseded in the later stages of the European stone age, comprising the neolithic period, by more finished articles of flint and other stone, many of which were brought into final shape by the processes of grinding and polishing. In North America stone implements likewise have been found associated with the osseous remains of extinct animals; yet these implements, it appears, differed in no wise from those in use among the aborigines at the period of their first intercourse with the whites.

In the year 1839, the late Dr. Albert C. Koch discovered in the bottom of the Bourbeuse River, in Gasconade County, Missouri, the remains of a *Mastodon giganteus* under very peculiar circumstances. The greater portion of the bones appeared more or less burned, and there was sufficient evidence that the fire had been kindled by human agency, and with the design of killing the huge creature, which had been found mired in the mud, and in an entirely helpless condition. The animal's fore and hind legs, untouched by the fire, were in a perpendicular position, with the toes attached to the feet, showing that the ground in which the animal had sunk, now a grayish-colored clay, was in a plastic condition when the occurrence took place. Those portions of the skeleton, however, which had been exposed above the surface of the clay, were partially consumed by the fire, and a layer of wood-ashes and charred bones, varying in thickness from two to six inches, indicated that the burning had been continued for some length of time. The fire appeared to have been most destructive around the head of the animal. Mingled with the ashes and bones was a large number of broken pieces of rock, which evidently had been carried to the spot from the bank of the Bourbeuse River to be hurled at the animal. But the burning and hurling of stones, it seems, did not satisfy the assailants of the mastodon; for Dr. Koch found among the ashes, bones, and rocks *several stone arrow-heads, a spear-head, and some stone axes*, which were taken out in the presence of a number of witnesses, consisting of the people of the neighborhood, who had been attracted by the novelty of the excavation. The layer of ashes and bones was covered by strata of alluvial deposits, consisting of clay, sand, and soil, from eight to nine feet thick, which form the bottom of the Bourbeuse River in general.

About one year after this excavation, Dr. Koch found at another place, in Benton County, Missouri, in the bottom of the Pomme de Terre River, about ten miles above its junction with the Osage, *several stone arrow-heads* mingled with the bones of a nearly entire skeleton of the Missourium. The two arrow-heads found with the bones "were in such a position as to furnish evidence still more conclusive, perhaps, than in the other case, of their being of equal, if not older date, than the bones themselves; for, besides that they were found in a layer of vegetable mold which was covered by twenty feet in thickness of alternate layers of sand, clay, and gravel, one of the arrow-heads lay underneath the thigh-bone of the skeleton, the bone actually resting in contact upon it, so that it could not have been brought thither after the deposit of the bone; a fact which I was careful thoroughly to investigate."*

Fig. 1.



It affords me particular satisfaction to present in Fig. 1 a full-size drawing of the last-named arrow-head, which is still in the possession of Mrs. Elizabeth Koch, of Saint Louis, the widow of the discoverer. The drawing was made after a photograph, for which I am indebted to Mrs. Koch. It will be noticed that the point, one of the barbs, and a corner of the stem of this arrow-head—if it really was an arrow-head, and not the armature of a javelin or spear—are broken off; but there remains enough of it to make out its original shape, which is exactly that of similar weapons used by the aborigines in historical times. The specimen in question, which, as I presume, was found by Dr. Koch in its present mutilated shape, consists of a light-brown, somewhat mottled flint.†

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*Koch, in Transactions of the Academy of Science of Saint Louis, vol. i, (1860,) p. 61, &c.

†I am well aware that the reality of Dr. Koch's discovery has been doubted by some, although it is difficult to perceive why he should have made those statements, if not true, at a time when the antiquity of man was not yet discussed, either in Europe or here, and he, therefore, could expect nothing but contradiction, public opinion being

In referring to these discoveries of Dr. Koch, and some other indications of the high antiquity of man in America, Sir John Lubbock concludes that "there does not as yet appear to be any satisfactory proof that man co-existed in America with the Mammoth and Mastodon."* Yet, it may be expected, almost with certainty, that the results of future investigations in North America will fully corroborate Dr. Koch's discoveries, and vindicate the truthfulness of his statements. Indeed, some facts have come to light during the late geological survey of Illinois, which confirm, in a general way, the conclusions arrived at by the above-named explorer. According to this survey, the blue clays at the base of the drift contain fragments of wood and trunks of trees, but no fossil remains of animals; but the brown clays above, underlying the Loess, contain remains of the Mammoth, the Mastodon, and the Peccary; and bones of the Mastodon were found in a bed of "local drift," near Alton, underlying the Loess *in situ* above, and also *in the same horizon, stone axes and flint spear-heads*, indicating the co-existence of the human race with the extinct mammalia of the Quaternary period.†

It must not be overlooked that both Dr. Koch and the Illinois survey mention flint arrow and spear-heads as well as stone axes as being associated, directly or indirectly, with the remains of extinct animals. These stone axes undoubtedly were *ground* implements; for, had they differed in any way from the ordinary Indian manufactures of the same class, the fact certainly would have been noticed by the observers. Thus far, then, we are not entitled to speak of a North American palaeolithic and neolithic period. In the new world, therefore, the human contemporary of the Mastodon and the Mammoth, it would seem, was more advanced in the manufacture of stone weapons than his savage brother of the European drift period, a circumstance which favors the view that the extinct large mammalia ceased to exist at a later epoch in America than in Europe. The remarks of Lieutenant-Colonel C. H. Smith on this point are of interest. "Over a considerable part of the eastern side of the great (American) mountain ridge," he says, "more particularly where ancient lakes have been converted into morasses, or have been filled by alluvials, organic remains of above thirty species of mammals, of the same orders and genera, in some cases of the same species, (as in Europe,) have been discovered, demonstrating their ex-

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totally unprepared for such revelations. Not being a scientific palaeontologist, he certainly made some mistakes in putting together the bones of the animals exhumed by him; but these failings, in my opinion, have no bearing on his observations relative to the co-existence of man with extinct animals in North America. Only a short time ago some remarks tending to depreciate Dr. Koch's account were made by Dr. Schmidt, in an article on the antiquity of man in America, published in vol. v, of the *Archiv für Anthropologie*. I may state here that I was personally acquainted with Dr. Koch, whom I saw repeatedly at the meetings of the Academy of Science of Saint Louis.

*Prehistoric Times, 1st ed., p. 236.

†Geological Survey of Illinois, by A. H. Worthen, vol. i, (1866,) p. 38; quoted in Transactions of the Academy of Science of Saint Louis, vol. ii, (1868,) p. 567.

istence in a contemporary era with those of the old continent, and under similar circumstances. But their period of duration in the new world may have been prolonged to dates of a subsequent time, since the Pachyderms of the United States, as well as those of the Pampas of Brazil, are much more perfect: and, in many cases, possess characters ascribed to bones in a recent state. Alligators and crocodiles, moreover, continue to exist in latitudes where they endure a winter state of torpidity beneath ice, as an evidence that the great Saurians in that region have not yet entirely worked out their mission; whereas, on the old continent they had ceased to exist in high latitudes long before the extinction of the great Ungulata."*

Flint implements of the European "drift type," however, are by no means scarce in North America, although they cannot (thus far) be referred to any particular period, but must be classed with the other chipped and ground implements in use among the North American aborigines during historical times.

In the first place I will mention certain leaf-shaped flint implements which have been found in mounds and on the surface, as well as in deposits below it. They are comparatively thin, of regular outline, and exhibit well-chipped edges all around the circumferences. On the whole, they are among the best North American flint articles which have fallen under my notice. The specimens found by Messrs. Squier and Davis in a mound of the inclosure called Mound City, on the Scioto River, some miles north of Chillicothe, Ohio, belong to this class. Most of them were broken, but a few were found entire, one of which is represented in half size by Fig. 100 on page 211 of the "Ancient Monuments of the Mississippi Valley." This specimen measures four inches in length and about three inches across the broad rounded end. I have a still larger one, consisting of a reddish mottled flint, which was found on the surface in Jefferson County, Missouri. The annexed full-size drawing, Fig. 2, shows its outline. The edge on the right side is a little damaged by subsequent fractures, but for the sake of greater distinctness I have represented it as perfect. The finest leaf-shaped implements which I have had occasion to examine, are in the possession of Mr. M. Cowing, of Seneca Falls, New York. The owner told me he had more than a hundred of them, which were all derived from a locality in the State of New York, where they were accidentally discovered, forming a deposit under the surface. Mr. Cowing, who is constantly engaged in collecting and buying up Indian relics, refused to give me any information concerning the place and precise character of the deposit, basing his refusal on the ground that a few of these implements were still in the hands of individuals in the neighborhood, and that he would reveal nothing in relation to the deposit until he had obtained every specimen originally belonging to it. I am, therefore, unable to give any particulars, and must confine myself to the statement that the specimens shown to me present in general the outline of the original of Fig. 2, though they are a little smaller; and that they are thin, sharp-edged, and exquisitely wrought, and consist of a beautiful, variously-colored flint, which bears some resemblance to chalcedony.

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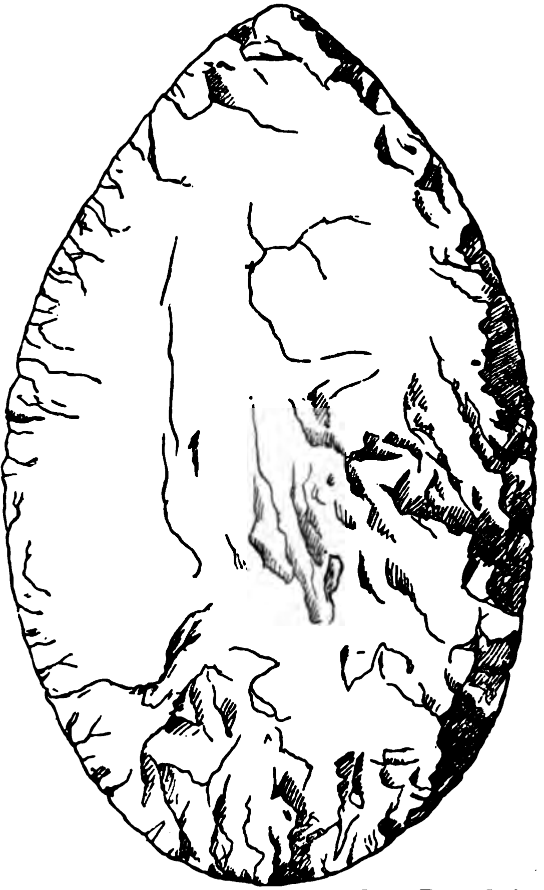
* The Natural History of the Human Species, London, 1852, p. 89. The comparative freshness of the bones of extinct North American animals was noticed by Cuvier.

Fig. 2.



Concerning the use or uses of North American leaf-shaped articles, I am hardly prepared to give a definite opinion, though I think it probable that they served for purposes of cutting. They were certainly not intended for spear-heads, their shape being ill-adapted for that end; nor do I think that they were used as scrapers, as other more massive implements of a kindred character probably were, of which I shall speak hereafter.

The aborigines were in the habit of burying articles of flint in the ground, and such deposits, sometimes quite large, have been discovered in various parts of the United States. These deposits consist of articles representing various types, among which I will mention the leaf-shaped implements in the possession of Mr. Cowing; the agricultural tools found at East Saint Louis, Illinois, of which I have given an account in the Smithsonian report for 1868; and the rude flint articles of an elongated oval shape, which were found about 1860 on the bank of the Mississippi, between Carondelet and Saint Louis, Missouri, and doubtless belonged to a deposit. I have described them in the above-named Smithsonian report, (p. 405,) and have also given there a drawing of one of the specimens in my possession. This drawing has been reproduced by Mr. E. T. Stevens, on page 441 of his valuable work entitled "Flint Chips," (London, 1870,) with remarks tending to show that the specimen does not represent an unfinished implement, as I am inclined to believe, but a complete one. I must admit that my drawing is not a very good one. It gives the object a more definite character than it really possesses, the chipping appearing in the representation far less superficial than it is in the original, which, indeed, has such a shape that it could easily be reduced to a smaller size by blows aimed at its circumference. I have myself scaled off large flat flakes from similarly-shaped pieces of flint, using a small iron hammer and directing my blows against the edge, and have thus become convinced that the further working of objects like that in question could offer no serious difficulties to a practised flint-chipper. My collection, moreover, contains several smaller flint objects of similar shape, which are undoubtedly the rudiments of arrow and spear-heads, and I may add that I obtained a few from places where the manufacture of such weapons was carried on.

Yet the most important deposit of flint implements resembling certain types of the European drift, is that discovered by Messrs. Squier and Davis during their researches in Ohio. They have described this interesting find in the "Ancient Monuments of the Mississippi Valley," and a *résumé* of their account was given by me in the Smithsonian report for 1868, (p. 404.) The implements in question, I stated, occurred in one of the so-called sacrificial mounds of Clark's Work, on North Fork of Paint Creek, Ross County, Ohio. This flat, but very broad mound contained, instead of the hearth usually found in this class of earth-structures, an enormous number of flint discs, standing on their edges and arranged in two layers, one above the other, at the bottom of the mound. The whole extent of these layers has not been ascertained, but an excavation six feet long and four broad disclosed upward of six hundred of those discs, rudely blocked out of a superior kind of dark flint. I had occasion to examine the specimens from this mound, which were formerly in the collection of Dr. Davis, and have now in my collection a number that belonged to the same deposit. They are either roundish, oval, or heart-shaped, and of various sizes, but on an average six inches long, four inches wide, and from three-quarters to an inch in thickness. These flint discs are believed to have been buried as a religious offering, and the peculiar structure of the mound which inclosed them rather favors this opinion, while their enormous number, on the other hand, affords some probability to the view that they constituted a depot or magazine. Many of them are clumsy, and roughly chipped around their edges; and hence it has been suggested that they are no finished implements, but merely rudimentary forms, destined to receive more symmetry of outline by subsequent labor. Many of the discs under notice bear a striking resemblance to the flint "hatchets" discovered by Boucher de Perthes and Dr. Rigollot in the diluvial gravels of the valley of the Somme, in Northern France. The similarity in form, however, is the only analogy that can be claimed for the rude flint articles of both continents, considering that they occurred under totally different circumstances. The drift implements of Europe represent the most primitive attempts of man in the art of working stone, while the Ohio discs, if finished at all, are certainly very rough samples of the handicraft of a race that constructed earthworks of astonishing regularity and magnitude, and was already highly skilled in the art of chipping flint into various shapes.

On page 214 of the "Ancient Monuments of the Mississippi Valley," a group of the flint articles from Clark's Work is represented. The drawing exhibits pretty correctly the irregular outline and general rudeness of these specimens; yet Mr. Stevens states (Flint Chips, p. 440) that "the representations are not at all satisfactory." The only fault, I think, that can be found with these drawings is their small scale, a fault which is very excusable, considering that at the period when Messrs. Squier and Davis published their work, (1848,) flint articles of such shape were no objects of particular attention; for just then the results of the researches of Boucher de Perthes were first laid before the scientific world, which, it is well known, ignored for a long time the significance of the rude flint tools discovered by the indefatigable and enthusiastic French savant in the diluvial gravel-beds of the Somme. It is true, however, that some of the flint discs of Clark's Work are wrought with more care than those represented in the "Ancient Monuments." This fact may be ascribed to a whim of the worker or workers, who gave some of the articles a greater degree of regularity by some additional blows. Mr. Stevens has only seen specimens of this better class, for such were those which Dr. Davis sold to the Blackmore Museum among his collection of Indian relics, and hence the author of "Flint Chips" seems to attribute to them a better general character than they really possess. I learn, however, that Mr. Blackmore, during a recent visit to Ohio, has succeeded in recovering a considerable number of the implements of Clark's Work, and thus an opportunity will be afforded again to investigate the true nature of these relics of a bygone people.

The objects in question consist of the compact silicious stone of "Flint Ridge," in Ohio, a locality described on page 214 of the "Ancient Monuments."* A careful comparison has established this fact beyond any doubt. The flint or hornstone which occurs in that region, is a beautiful material of a dark color, resembling somewhat the real flint found in nodules in the cretaceous formations of Europe. It is occasionally marked with darker or lighter concentric stripes or bands, the centre of which is formed by a small nucleus of blue chalcedony; and this internal structure appears particularly distinct in specimens which, by exposure, have undergone a superficial change of color. The stone, in general, possesses peculiarities by which it can be recognized at once, even when met in a wrought state far from its original site. According to Mr. Squier, arrow-heads made of this hornstone have been found in Kentucky, Indiana, Illinois, and Michigan. That they occur in Illinois, I can attest from personal experience.

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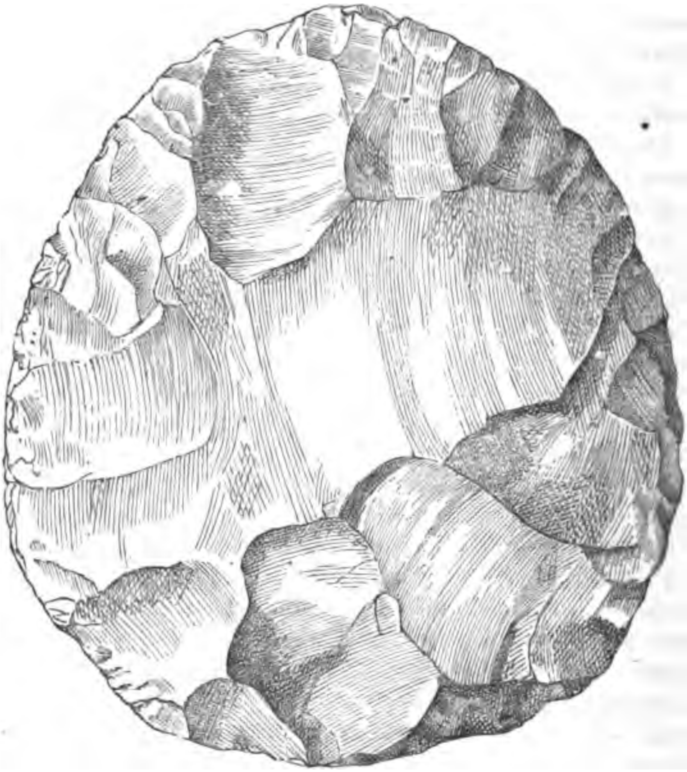
* More particularly in Squier's "Aboriginal Monuments of New York," Buffalo, 1851, p. 126.

A few years ago, when treating of the flint implements of Clark's Work, I was not prepared to express a definite opinion concerning the manner in which they were used. In the mean time, however, I have obtained additional information in relation to the class of implements under notice, which enables me, as I think, to point out the purposes for which those of Clark's Work, as well as similar ones from other localities, were designed. In the summer of 1869, some children, who were amusing themselves near the barn on the farm of Oliver H. Mullen, in the neighborhood of Fayetteville, Saint Clair County, Illinois, dug into the ground and discovered a deposit of fifty-two disc-shaped flint implements, which lay closely heaped together. Several of them came into my possession through the assistance of Dr. Patrick, of Belleville, in the same county. They consist, like those of Clark's Work, of the peculiar stone of Flint Ridge. This I noticed at first sight, and so did Messrs. Squier and Davis, to whom I showed them. They resemble, in general shape, the objects of Clark's Work, but are somewhat smaller and of perfectly symmetrical outline, having a well-chipped, though strong edge; in one word, they are highly finished implements, far superior to those of Clark's Work. In Fig. 3 I give a full-size drawing of one of my speci-

Fig. 3.



mens from Fayetteville, which is twenty millimeters thick in the middle. The slight irregularities observable in the circumference are owing to later accidental fractures. In this specimen, as in the others from the same find, the edge is produced by small, carefully-measured blows. The edges of my specimens from Fayetteville, moreover, exhibit traces of wear, being rubbed off to a small degree, and this circumstance, in connection with their shape, induces me to believe that they were used as *scraping* or *smoothing implements.* The aborigines, it is well known, hollowed their canoes and wooden mortars with the assistance of fire, and the implements just described, were, as I presume, employed for removing the charred portions of the wood. They are well adapted to the grasp of the hand, and, indeed, of the most convenient form and size to serve in that operation. Probably they were likewise used in cleaning hides, and for other purposes. The tools of Fayetteville, however, are much more handy than those of Clark's Work.

The fact that implements made of the hornstone of Flint Ridge are found in Illinois—a distance of about four hundred miles intervening—is of particular interest, as it shows that the material was quarried for exportation to remote parts of the country. It doubtless formed an article of traffic among the natives, like copper, sea-shells, and other natural productions which they applied to the exigencies of common life or used for personal adornment.

Concerning North American flint implements of the European drift type in general, Mr. Stevens expresses himself thus: "The legitimate conclusion at which we may at present arrive, is that implements, in form resembling some of the European palaeolithic types, were made by the aborigines of America at a comparatively late period, and that the people usually termed the 'mound-builders,' were, probably, the makers of these implements." (p. 443.)

There is no sufficient ground, I think, for attributing these implements exclusively to the mound-builders, considering that they occur on the surface, and in deposits below it, in regions where the people designated as the mound-builders are not supposed to have left their traces. In the States of New York and New Jersey, for instance, such articles repeatedly have been met. I will only refer to the leaf-shaped implements in possession of Mr. Cowing, which were found in New York, and are the finest specimens of that kind ever brought to my notice. That the people who erected the mounds made and used tools resembling the palaeolithic types of Europe, is proved by the occurrence of those tools in the mounds; but it follows by no means that they are to be considered as the sole makers of that class of implements. Supposing that the mound-builders really were a people superior in their attainments to the aborigines found in possession of the country by the whites, it is certainly very difficult to draw a line of demarcation between the manufactures of the ancient and those of the more recent indigenous inhabitants of North America. The mound-builders—to preserve the adopted term—certainly did not stow away all their articles of use and ornament in the mounds, but necessarily left a great many of them scattered over the surface, which became mingled with those of the succeeding occupants of the soil. Both the mound-builders and the later Indians lived in an age of stone, and as their wants were the same, they resorted to the same means to satisfy them. Their manufactures, therefore, must exhibit a considerable degree of similarity, and hence the great difficulty of separating them.

Yet Mr. Stevens goes in this respect farther than any one before him. He is particularly orthodox in the matter of pipes. Those who have paid some attention to the antiquities of North America, are aware of the fact that Messrs. Squier and Davis found in the mounds of Ohio, especially in one mound near Chillicothe, a number of stone pipes of peculiar shape, which they have described in the "Ancient Monuments of the Mississippi Valley." In these pipes the bowl rises from the middle of a flat and somewhat curved base, one side of which communicates by means of a narrow perforation, usually one-sixth of an inch (about four millimeters) in diameter, with the hollow of the bowl, and represents the tube, or rather the mouth-piece of the pipe, while the other unperforated end forms the handle by which the smoker held the implement and approached it to his mouth. In the more elaborate specimens the bowl is formed, in some instances, in imitation of the human head, but generally of the body of an animal—mammal, bird, or reptile. These pipes, then, were smoked either without any stem, which seems probable, or by means of a very diminutive tube of some kind, the narrow bore of the base not allowing the insertion of anything like a massive stem. The authors of the "Ancient Monuments" called these pipes "mound-pipes," merely to designate that particular class of smoking utensils; it was not their intention to convey the idea that the mound-builders had been unacquainted with pipes into which stems were inserted. On the contrary, they distinctly assign a beautiful pipe of the latter kind, representing the body of a bird with a human head* to the mound-builders, though this specimen was not found in a mound, but within an ancient inclosure twelve miles below the city of Chillicothe. Referring to this pipe, Mr. Stevens says: "Squier and Davis consider that this object is a relic of the mound-builders; but it does not appear that any pipe of similar form, or indeed *any* pipe intended to be smoked by means of an inserted stem, has been found in any of the Ohio mounds." Upon inquiry I learned from Dr. Davis that mounds had been leveled by the plough within the inclosure where the pipe in question was found, which, he is convinced, belonged to the original contents of one of those obliterated mounds. In the Smithsonian report for 1868, I published (on page 399) the drawing of a pipe then in possession of Dr. Davis. Its shape is that of a barrel somewhat narrowing at the bottom, and its material an almost transparent rock-crystal. The two hollows, one for the reception of the smoking material, and the other for inserting a stem, meet under an obtuse angle. This pipe was taken from a mound near Bainbridge, Ross County, Ohio. Mr. Stevens suggests it had been associated with a secondary interment, (p. 524.) Dr. Davis, however, who is acquainted with the circumstances of its discovery, told me that it belonged, with various other objects, to the *primary* deposit of the mound. Thus it would seem that the mound-builders confined themselves by no means to the use of one particular class of pipes.

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* Fig. 147 on p. 247 of the "Ancient Monuments;" Fig. 106 on p. 509 of "Flint Chips."

Those who advocate a strict classification of North American relics according to earlier or later periods, should bear in mind that mound-building was still in use—if not in Ohio, at least in other parts of the present United States—when the first Europeans arrived, though the practice seems to have been abandoned soon after the colonization of the country by the whites. Yet, even in comparatively modern times, isolated cases of mound-building have been recorded,* which fact would indicate, perhaps, a lingering inclination to perpetuate an ancient, almost forgotten custom. Many of the earthworks in the Southern States doubtless were built by the race of Indians inhabiting the country when the Spaniards under De Soto made a vain attempt to take possession of that vast territory, then comprised under the name of Florida. For this we have Garcilasso de la Vega's often-quoted statement relating to the earth-structures of the Indians. The Floridians, we also know, erected at the same period mounds to mark the resting-places of their defunct chieftains. Le Moyne de Morgues has left in the "Brevis Narratio" a representation and description of a funeral of this kind. When the mound was heaped up, the mourners stuck arrows in the ground around its base, and placed the drinking vessel of the deceased, made of a large sea-shell, on the apex of the pile.† But even without such historical testimony, the continuance of mound-building might be deduced from the fact that articles of European origin are met, though rarely, among the primary deposits of mounds. The following interesting communication, for which I am indebted to Colonel Charles C. Jones, will serve to illustrate one case of mound-burial that can be referred with certainty to a period posterior to the European occupation of the country:

"I have found in several mounds," says my informant, "glass beads and silver ornaments, and, in one instance, a part of a rifle-barrel, which were evidently buried with the dead. These, however, were secondary interments, the graves being upon the top, or sides, or near the base of the mound, and only a few feet deep. Never but in one case have I discovered any article of European manufacture interred with the dead in whose honor the mound was clearly erected. Upon opening a small earth-mound on the Georgia coast, a few miles below Savannah, I found a clay vessel, several flint arrow-heads, a hand-axe of stone, *and a por-*

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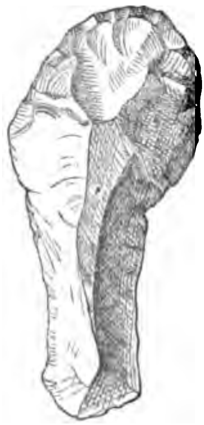
* Squier, Aboriginal Monuments of New York, p. 112, &c.

† Le Moyne, in De Bry, vol. ii, Francoforti ad Moenum, 1591, pl. XL.

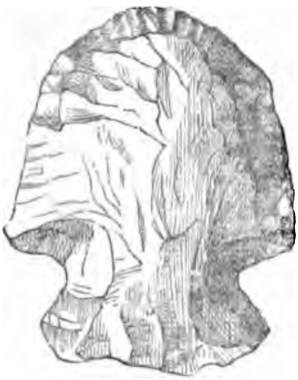
tion of an old-fashioned sword deposited with the decayed bones of the skeleton. This tumulus was conical in shape, about seven feet high, and possessed a base diameter of some twenty feet. It contained only one skeleton, and that lay, with the articles I have enumerated, at the bottom of the mound, and on a level with the plain. The oaken hilt, most of the guard, and about seven inches of the blade of the sword still remained. The rest of the blade had perished from rust. Strange to say, the oak had best resisted the 'gnawing tooth of time.' This mound had never been opened or in any way disturbed, except by the winds and rains of the changing seasons. I have no doubt but that the interment was primary, and that all the articles enumerated were deposited with the dead before this mound-tomb was heaped above him. This, within the range of my observation, is an interesting and exceptional case. I am persuaded that mound-building, at least upon the Georgia coast, was abandoned by the natives very shortly after their primal contact with the whites."

Fig. 4.



From mound-building I turn again to North American flint implements. Mr. Stevens refers in his work to the absence of flint scrapers in the series from the United States exhibited in the Blackmore Museum. Scrapers of the European spoon-shaped type, however, are not as scarce in the United States as Mr. Stevens seems to suppose. The collection of the Smithsonian Institution contains a number of them; and I found myself two characteristic specimens in the Kjökkenmödding at Keyport, New Jersey, described by me in the Smithsonian report for 1864. They lay upon the shell-covered ground, a short distance from each other, and were perhaps made by the same hand. In Fig. 4 I give a full-size drawing of one of my specimens, both of which consist of a brown kind of flint, such as probably would be called jasper by mineralogists. The figured specimen, it will be seen, possesses all the characteristics of a European scraper. Its lower surface is formed by a single curved fracture. The rounded head is somewhat turned toward the right, a feature likewise exhibited in the other specimen, which is a little larger, but not quite as typical as the original of Fig. 4. As the peculiar curve of the broad part is observable in both specimens, it must be considered as having been produced intentionally. Indeed, I have among my flint scrapers from the pilework at Robenhausen one which is curved in the same direction. In fashioning their implements in this particular manner, the Indian and the ancient lake-man possibly had the same object in view.

Fig. 5.



There is, however, another somewhat different class of North American flint articles, which, as I believe, were employed by the aborigines for scraping and smoothing wood, horn, and other materials in which they worked, or perhaps, also, in the preparation of skins. They resemble stemmed arrow-heads, which, instead of being pointed, terminate in a semi-lunar, regularly chipped edge. It is probable that they were partly made from arrow-heads which had lost their points. Schoolcraft gives in Fig. 3, of Plate 18, in the first volume of his large work, the drawing of an object of this class, calling it "the blunt arrow or *Beekwuk*, (Algonkin,) which was fired at a mark." It is likely enough that these articles served in part the purpose assigned to them by Mr. Schoolcraft. Yet, I have in my collection several in which the rounded edge is worn and polished, while the remaining part retains its original sharpness of fracture, a circumstance that can only be ascribed to continued use, and therefore leads me to believe that they were employed in the manner already indicated. These implements hardly could be used without handles. Fig. 5 represents, in natural size, one of my specimens, which was found on the surface near West Belleville, Saint Clair County, Illinois. The material is a yellowish-brown flint. The edge, it will be seen, is perfectly scraper-like. Inserted into a stout handle, this object would make an excellent scraper. The edge of this specimen is not polished, but it seems as if small particles of the edge had been scaled off by the pressure exerted in the use of the implement. In the original of the above full-size representation, Fig. 6, on the contrary, the curved edge is rubbed off to a considerable extent and perfectly polished, while the portion opposite the edge bears not the slightest trace of friction. This specimen, which consists of a whitish flint, was found in Saint Clair County, Illinois. In Fig. 7, lastly, I represent, in natural size, a fine large specimen, which I class among the implements under notice. I formerly supposed it to be a tool destined for cutting purposes, but the condition of the edge, which is rather blunt and hardly fit for cutting, afterward induced me to change my

Fig. 6.

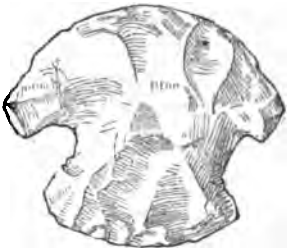
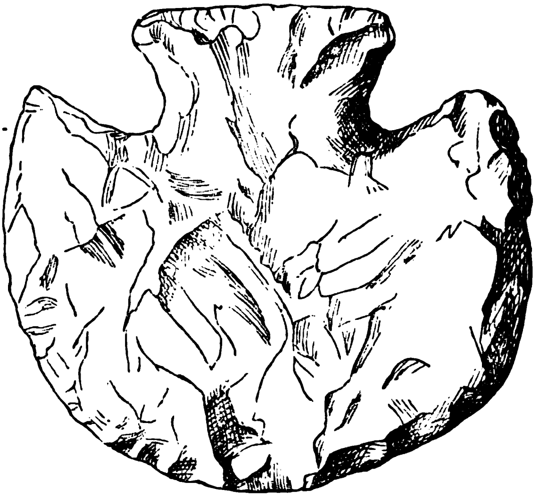


Fig. 7.



opinion. Originally, perhaps, one of those unusually large spear-heads, which are occasionally found, it may have been reduced subsequently, after having lost the point, to its present shape. Yet, it may never have possessed a form different from that which it now exhibits. This specimen is chipped from a fine reddish flint which contains encrinites. I obtained it from quarrymen near West Belleville, who found it in the earth while they were engaged in baring the rock for extending the quarry. In conclusion, I will state that, since writing the preceding pages, I received a number of stone implements from Muncy, Lycoming County, Pennsylvania, among which there are some large scrapers of the European type. Their material, however, is not flint, but either graywacke or a kind of tough slate.

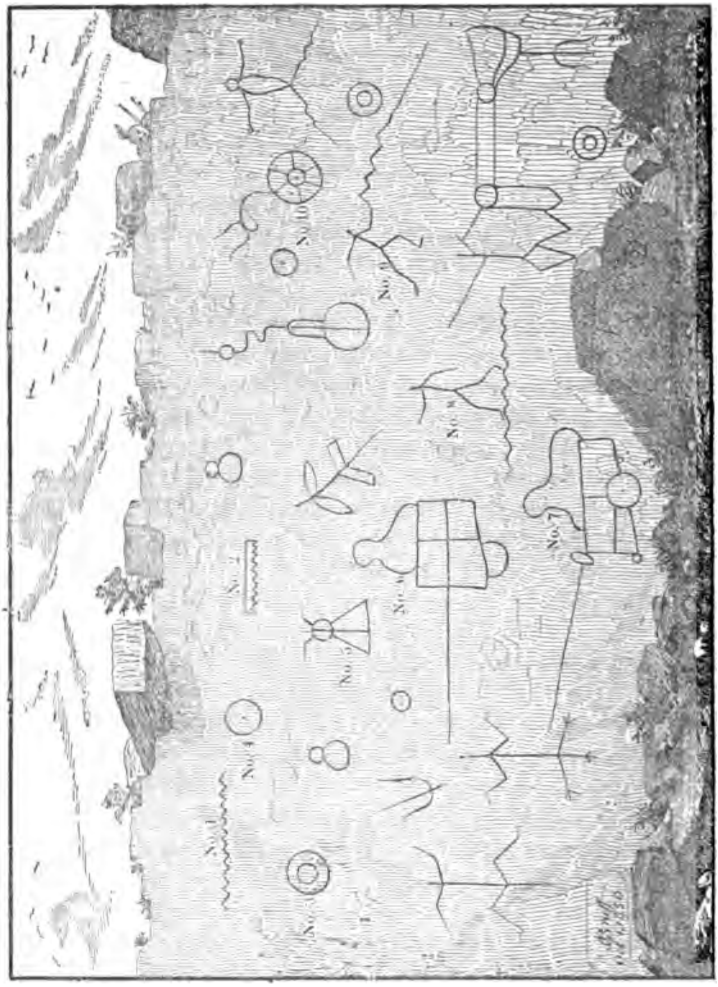
INDIAN ENGRAVINGS ON THE FACE OF ROCKS ALONG GREEN RIVER VALLEY IN THE SIERRA NEVADA RANGE OF MOUNTAINS.

By J. G. Bruff.

In 1850, accompanied by a party of twenty-three persons in all, well mounted and armed, I explored a mountain district probably never before visited by the whites. The Pi-utah Indians, numerous and hostile, annoyed us much, stole a horse, and killed one of the party. I had a pocket-compass, a protractor, scale, and dividers, with which, taking the bearings of the snow-capped peaks of Shasta and Mount Saint José, or Lassen's Peak, I fixed our position upon the map. We soon commenced descending the eastern slope of the mountain, following ridges and valleys through what Lassen, who was one of the party, very aptly termed "a blown-up country." It is all of volcanic origin, with fissures, extinct craters, obsidian, &c., &c. At length, descending the side of an extensive ridge, by an Indian or brute trail, we reached a gulch-head, in which was a delightful spring of clear water, the source of a stream, at first a mere brook, which after a few hours' ride became a considerable creek, bordered with a luxuriant growth of willows, grass, and trees of all sizes. From near the spring commenced a volcanic rent, running in a general northeasterly direction diagonally across an extensive inclined sterile plain, covered with sharp angular blocks of a brown plutonic rock, among which, through this defile, the creek meandered. All indications showed this to be a favorite resort of Indians. Game abounded; tracks of grizzly bears, deer, antelopes, panthers, wolves, &c., were seen at the numerous crossings of the stream, with several shooting-lodges of the natives, one of which I sketched. We traveled at a quick pace the greater part of the day, in this defile, in imminent danger from the Indians, who might from the willow jungles, or from the top of the walls, have unhorsed the entire party with their obsidian-pointed arrows. The southern side of the defile was a vertical wall, as of masonry; the other was irregular and broken. From its head the creek-bottom, having a greater declination than the general surface, gave the walls more height, until the southern one was on an average 20 feet. Several large blocks of stone occasionally projected over the wall, and the top all along was very irregular, with rocks and clumps of cedar-bushes. But that which was the principal point of interest in this defile of some fifteen or twenty miles in length was the fact that the surface of the rock was covered with sculptured characters. (Fig. 1.) The highest ranges of these remarkable records, some of which are cut in the under face of overhanging rocks, could only have been executed by the aid of platforms. The rock is of such a hard nature that in order to make similar markings we would be compelled to use a well-tempered chisel and hammer. They are generally of the size of a crow-quill, say one-tenth of an inch, but were originally greater. Some, here and there, were partially obliterated by the action of the elements for many years.

The labor and time required to execute these engravings are sufficient proof of their importance to the people who produced them. We at length came to a rugged pile of *detritus*, where the wall had been broken down, perhaps by the action of frost, and clambered up to the plain above, from whence I perceived the dark line of the ravine trending away in the same general direction, till lost to view in a distance of about twelve or fifteen miles, the markings doubtless extending all the way. The same amount of markings roughly executed with a brush would involve the labor of many painters for several months. The creek doubtless emptied into the northern end of a lake, which we discovered soon after, which, from a delicious manna found on its banks, we named Honey Lake. Being greatly interested in these historical records, I could not resist the temptation of copying some of them. The party proceeded, and

Fig. 1.



ANCIENT HIEROGLYPHICAL RECORDS, covering the basaltic walls of a defile of many miles in extent, averaging, perhaps, 20ft. in height, on the eastern slope of the SIERRA NEVADA MOUNTAINS. Discovered by J. G. BRUFF, Oct. 1 1850. [*Selections on a large scale.*]

called back to me in the most emphatic terms to come on, or I would be caught by the Indians. Two young men volunteered, however, to guard me while I sketched, and, with cocked rifles, watching the top of the wall, urged me to get through as speedily as possible, making use of those cogent expletives found only in the vocabulary of such characters. It might truly be deemed sketching under difficulties.

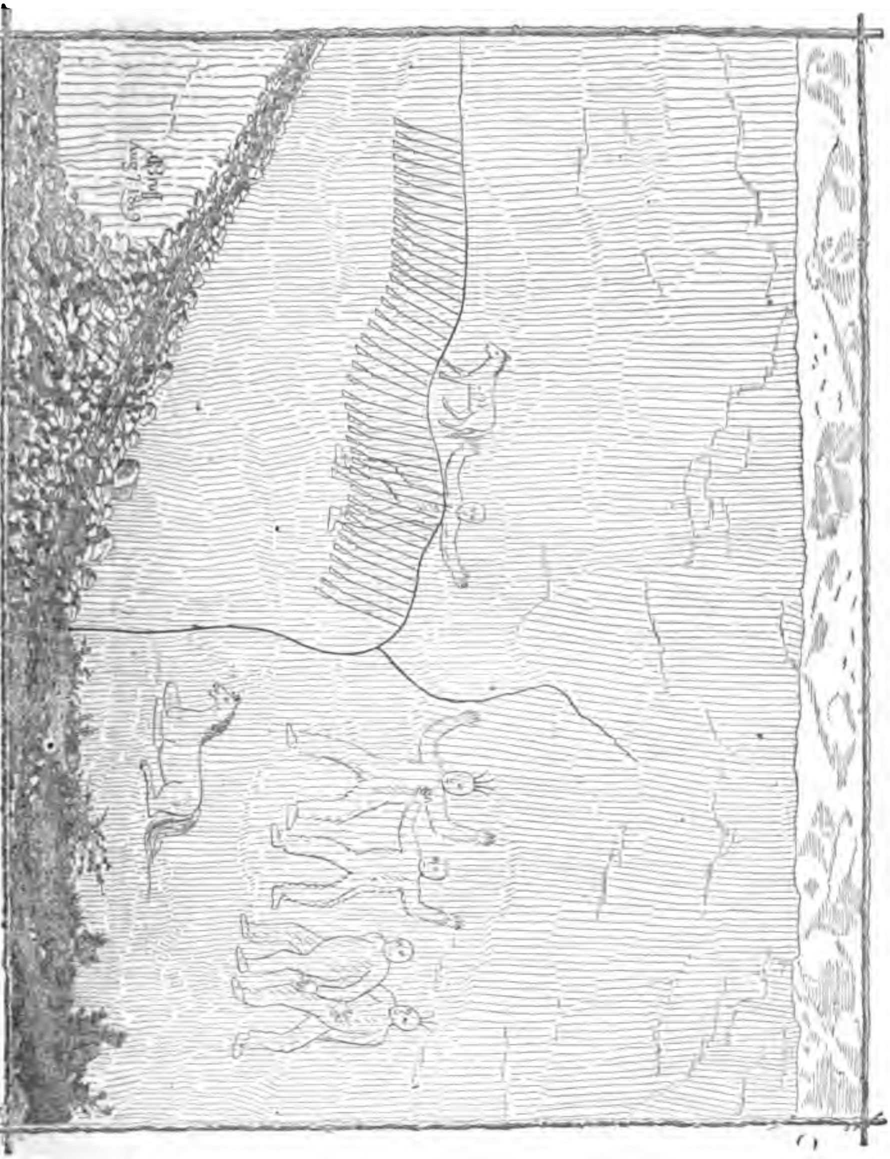


Fig. 2.

INDIAN RECORD, on a sandstone cliff, western side of the valley of Green River, upon the western slope of the Rocky Mountains.

Figure 2 exhibits forty-three rifles, a small lean horse, his ribs being visible, and a principal chief; stretched along the main branch of the stream. On the other side, north of the main stream, are two chiefs, two braves, and a good-conditioned horse at rest. It is on a vertical cliff of fine gray sandstone, at the foot of an inclined plane, where the trail runs into the valley from the elevated land dividing it from La Fontenelle Creek. The significance of the record appears to me as follows: The forty-three mounted warriors had left an impoverished district, and descended to this valley, full of grass, fuel, game, &c., whereby they were enabled to recruit themselves and become successful in their expedition. The drawing is not in proportion. The men were about 3 feet above the base, and not 3 feet in height. Assuming the tallest man to be 3 feet in height, 3 feet from ground, and the cliff 12 feet, the other proportions will be sufficiently correct. The markings when first observed were almost entirely obscured with dust; but, with a small branch of a tree, I dusted off the surface of the rock, and copied them in rough sketches in my note-book.

ANCIENT RUIN IN ARIZONA.

By J. C. Y. Lee.

In the heart of the Pinal Mountains in Arizona, and the center of what is known as the Apache country, is a little valley of not more than 150 acres in extent. This valley is sometimes called Mason's Valley, after General Jno. S. Mason, major of the Fifteenth Infantry, by whom, when commanding the district of Arizona, in 1864, it was discovered. It is a beautiful valley, with groves of luxuriant trees, green sward, and abundant foliage, by no means common in this Territory. Its altitude is probably about 5,000 feet above the level of the sea, and from 3,500 to 4,000 feet above the table-land, at the base of the mountains. Around it, to great heights, on every side save two passes, one to the eastward and one to the westward, rise the peaks of the Pinal Mountains, very abrupt and very picturesque. From the summit of these, far away eastward and northward, stretch, in unending succession, mountain-peaks, cañons, and chasms. I have never seen so rough a country, and have no words to adequately describe it.

While exploring this region, under orders from General Stoneman, we found in the valley described the remains of a very extensive building. No walls were left standing, but the stone foundations were distinct, so that the apartments could still be easily traced. There could not have been less than twenty or thirty rooms, some of which were very large, and others small. The ruin was on a little eminence, or mound of gravel, but whether so constructed originally, or whether the mound had been formed by the falling walls, it was impossible to tell. About the spot, pieces of broken earthen-ware were discovered, of which the accompanying pieces are samples. They are better finished than those now made by the Indians, and seem of different composition. By whom the building was erected, or by whom inhabited, I cannot determine; whether it had been the home of the Jesuits during the period of their residence in this country, is not clear, as the place indicates the building to be of a date prior to that epoch; and, besides, most of their buildings are yet standing.

The place is so remote and inaccessible that I can hardly suppose the Jesuits would have reached it. And as the Apaches have held the region for long, long years, so long that it is looked upon by them as their original home, and is certainly their stronghold, I incline to the opinion that it is an ancient Aztec or Toltec ruin.

THE HAYSTACK MOUND, LINCOLN COUNTY, DAKOTA.

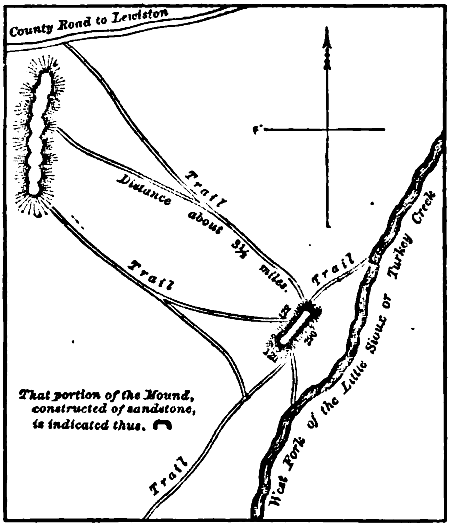
BY A. BARRANDT, OF SIOUX CITY.

This mound, one of the finest specimens of archæological remains in the Northwest, is situated in Lincoln County, near the west fork of the Little Sioux of Dakota or Turkey Creek, nearly eighty-five miles northwest of Sioux City. It is situated on a fine bottom, and is 327 feet in length at the base on the northwest side, and 290 feet on the southeast side, and 120 feet wide. Its sides slope at an angle of about 50°; it is from 34 to 41 feet in height, the northeast end being the higher. To the summit, which is from 28 to 33 feet wide, there is a well-beaten path. It is composed of calcined clay, which by burning has become hard and of a dark brick color. Toward its base on the northeast side there is a large portion of the side built of soft sandstone and limestone, which were probably extracted from the large hill lying about three miles and a half in a northwesterly direction, as I have found a large hole in the side hill partially filled by the caving in of the bank. At first I thought that it was a spur of the main ridge of hill that had been isolated by the action of water which in former ages rushed down that valley, as the cut banks on both sides of the creek clearly indicate; but, on closer examination, I found that it was built of the above-mentioned materials. What led to making a part of the mound with stone, I am at a loss to conjecture. While examining the mound, I discovered on its southeast side a hole which had all the appearance of a badger-hole; it was about 18 feet from the base of the mound. I determined to ascertain whether it was a badger-hole or some inlet which in the course of time might have been filled up by the falling *débris*. I accordingly had a hole dug, and, after reaching a distance of 23 feet horizontally, discovered a cavity which was found to contain a part of the vertebra of an elk, several bones, belonging probably to the same animal, and thirty-six broken fragments of pottery, together with a pile of ashes and about half a bushel of charcoal, and charred wood. This cavity was nearly circular, about 7 feet in diameter, and about 3½ or 4 feet high.

I conjectured that at one time this cavity must have reached the summit of the mound, and consequently I ordered that a hole should be dug as nearly as possible above it. After having dug to the depth of 9 feet, we came to within two feet of the cavity. Here we found several large sand-stones and a stick of oak, very well preserved, projecting over the top of the cavity. This stick was probably used as a support for pots hung over the fire, for that the culinary art was practiced in this hole is clearly indicated by the ashes and bones strewn around. But how this hole got filled up, I am at loss to determine. I am sanguine that if the mound was properly explored some valuable relics of this industrious race of mound-builders would be found; owing to its being at a distance from the banks of the Missouri, and the generally traveled road, it has never been examined by any scientific explorer. From afar it resembles a haystack, and hence this name was given to it by the emigrant.

Annexed you will find a sketch, which will probably give a better idea of its locality and surroundings:

Sketch of the Haystack Mound, Lincoln County, D. T.


County Road to Lewiston
Trail
Distance about 3½ miles.
Trail
Trail
12
30
12
Trail
West Fork of the Little Sioux or Turkey Creek
That portion of the Mound, constructed of sandstone, is indicated thus.

EARTH-WORKS IN WISCONSIN.

By E. E. Breed.

Presuming that any notes relating to the aboriginal inhabitants of this State would be of service to you, I submit the following.

There is a series of pits on the northwest of the northwest section 10, and northeast of the northwest section 10, township 25, range 15 east, (town of Matteson.) The pits are in an irregular line, general direction from northwest to southeast, from four to six rods apart. Quite a number are in pairs. The depth, as found by excavating the earth that had caved in, was originally from 4 to 5 feet, diameter 3 feet. In almost every instance the earth was thrown out on the southwest side. Soil sandy.

A few years ago the land was covered by a heavy growth of timber, principally hemlock. Trees over two hundred years old grew on the earth that had been thrown out. The chain is broken by a small pond, perhaps ten rods across, but follows a sandy ridge most of the way. The site is just such as might be selected to form a line of defense.

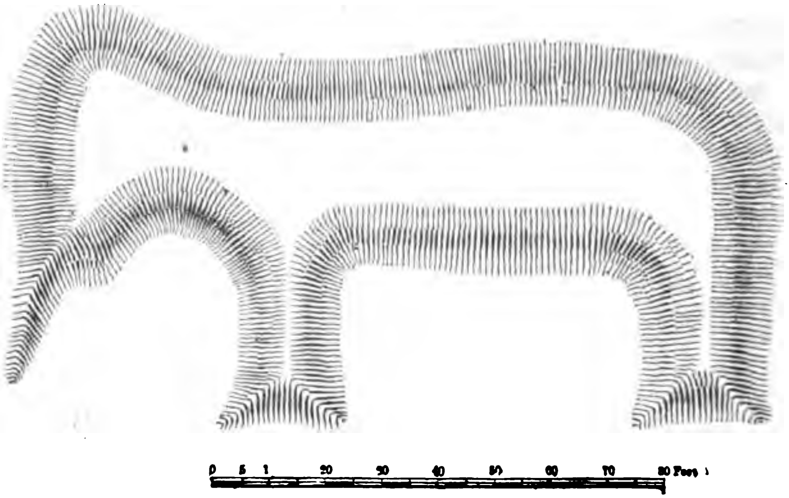
MOUND IN WISCONSIN.

By C. K. Dean, Boscobel, Grant County, Wisconsin.

We have, or *had*, in the Wisconsin Valley, which I have seen and sketched in part, many curious mounds resembling animals, those of flying birds being the most common; but nothing in the shape of an elephant or any extinct animal. The most striking among my notes is one in the form of a *man*, immense in proportions, sketched twenty years ago at Black Earth. The other in the shape of a huge *molar tooth*. This was in the town of Dover, about fifty miles above us. I saw the man-mound the next day after it had been opened at the breast to the natural level of the ground, and observed that it was designed as a tomb and memorial of some one evidently distinguished in life. The tomb was made from a blue-clay, brought in balls from some distance—none such near—was well packed and smooth, and of full length. The walls near two feet thick, inclosing a vacant space containing traces of burial of one, or perhaps two bodies. A few relics of little importance were reported—two stone hatchets, some arrow-heads, &c., which I did not see; but ashes and the smell of mortality were still there. The arms of this figure were extended north and south, each 330 feet in length, or about 700 feet altogether, including the width of the body, and the body to the east about 100 feet in length. The legs were partially obliterated by cultivation of the ground, but were evidently about 600 feet long. The head was about 25 feet in diameter, and the elevation of the body above the surface of the ground about 5 feet.

THE BIG ELEPHANT MOUND IN GRANT COUNTY, WISCONSIN.

By Jared Warner, of Patch Grove, Wisconsin.



Scale 34 feet to the inch.

This mound has been known here for the last twenty-five years as the "Elephant Mound." It is situated on the high sandy bottom-lands of the Mississippi, on the east side, about eight miles below the mouth of the Wisconsin River. There are on each side of the mound, some fifteen to twenty rods distant, sandy, grassy ridges, some 15 feet higher than the land about the mound; the mound is, therefore, in a shallow valley, sloping gently to the Mississippi River, and only about 8 feet above high water. Its total length is 135 feet; from hind feet to back, 60 feet; from fore feet to back, 66 feet; width across fore legs, 21 feet; across hind legs, 24 feet; from end of proboscis or snout to neck or throat, 31 feet; space between fore and hind legs, 51 feet; from end of proboscis to fore legs, 39 feet; across the body, 36 feet; general height of body above surrounding ground, 5 feet. The head is large, and the proportions of the whole so symmetrical that the mound well deserves the name of the "Big Elephant Mound."

The figure is from a drawing taken on the ground, in company with Alex. Paul, J. C. Orr, and J. C. Scott, in October, 1872.

Is not the existence of such a mound good evidence of the contemporaneous existence of the mastodon and the mound-builders, and also of the very small change, if any, of the present bed of the Mississippi River?

There are many mounds in the form of animals in this section of country which I have seen within the last thirty-five years; namely, in the shape of birds, bears, deer, foxes, and men, the latter with legs only to the knees.

ANCIENT RELICS IN NORTHWESTERN IOWA.

BY J. B. CUTTS.

During a recent journey over Northwestern Iowa I found some fragments of ornamented pottery-ware under circumstances of sufficient interest to induce me to forward to you a brief account of them. I obtained these fragments from about three feet below the surface of the ground, on the banks of Little Sioux River, in township 93, range 39.

The valley of the river is about one mile in width between the line of bluffs on each side, and through the middle of this valley the river has cut its present channel, leaving a terrace on either side, the level of which is from 10 to 12 feet above the water.

A section of the bank presents a grayish clay at the bottom, covered by 6 or 8 feet of alluvial soil, free from rocks or gravel, and composed principally of transported loess. In this upper deposit I excavated and obtained in the course of half an hour nearly half a peck of fragments, in pieces from the size of an inch to several inches square, and from one-eighth to one-half an inch in thickness. In many cases these fragments were ornamented on the outside surface by cross and parallel lines and indentations, the whole exhibiting considerable skill in fashioning the material, as well as taste in its ornamentation. There were evidently vessels of various size and degrees of ornament. They were found, as before stated, about 3 feet below the surface. First, at the bottom, occurred a row of stones, each about the size of a man's fist, and arranged in the form of a circle, as is often done in building fires to boil one's coffee in the open air. From the center of this circle I obtained several pieces of charcoal of the size of my thumb. Above this circle of rocks were found the pieces of pottery, and above these the bones of animals, which my companion pronounced to be those of the buffalo, elk, and beaver. The order of arrangement at once suggested a fire built within a small circle of rocks, on which rested the pottery vessels filled with the flesh of animals, either for ordinary cookery or as a part of that Indian custom which supplied the dead with provisions for their long journey, the whole being then covered with earth, the weight of which has broken the vessels and pressed itself into every interstice, but left the order of succession plain. I could find no human remains during my brief examination; no traces of mounds or Indian residence in the neighborhood.

The depth below the surface at which these articles were found forbids the supposition of their being of *late date.*

The country has been settled by whites only within five or six years past.

MOUNDS NEAR ANNA, UNION COUNTY, ILLINOIS.

By T. M. Perrin.

The most extensive works of the mound-builders in this county are situated in the Mississippi bottom, fifteen miles from Anna. At that point the creek makes a bend resembling very much in shape a horseshoe, which renders the place very favorable for a defensive work. The earth-work follows the bend in the creek, and is, at this time, about 4 feet high. The entrance to the inclosure is on the south side, with a large oblong mound in front of the opening. This mound is about 30 feet by 50, and about 30 feet high at the highest point, with a depression in the center, which makes it appear in profile like a double mound.

West of this mound, a short distance, is a round mound about 30 feet in diameter and 15 feet high. The earth-work incloses about twenty acres. Within the area of the inclosure there is another mound covering about two acres, which is evidently a sepulchral remain, as a large number of skeletons have been found in it, none of them perfect, however, though the earth is compact and dry. The skulls are very large, but fall to pieces on being exposed to the air. One skull has been found that would have measured 36 inches in circumference. The skeletons in this mound were all carefully inclosed with flat stones, each skeleton being separate.

The other mounds appear to have been used for another purpose, probably for defense, as nothing has been found in them. Half of the inclosure, as well as all the mounds, are in a cultivated field. The round mound to the west of the opening and part of the earth-work are in the woods, and covered with large timber. In the sepulchral mound are found pottery-ware, and stone and flint articles, but no metal or bone implements. One mile northeast of this, on a high beach-flat, and overlooking a lake, is another sepulchral mound, but no earth-work. In this mound nothing was found with the skeletons. This, like the former, has stone around each skeleton, but the grave is not more than 3 feet long and 18 inches deep. The body must have been buried with the feet drawn up to the trunk.

Five miles north of this there is another mound, on the top of the highest hill in the vicinity, and bordering on Bluff Lake. Nothing has been found in connection with this except two or three copper rings—no skeletons, although indications are that it has been used for burial purposes.

About one and a half miles northwest of the last-mentioned mound there is another sepulchral mound, but as it is in a cultivated field it is now very nearly level with the surface of the ground; but only recently have any skeletons been found in it, which tends to show that they were buried in the bottom of the mound and are brought to light every year as the plow removes some of the stones placed around the graves.

The parts of skeletons found here are very long. The skulls crumble at the slightest touch, but the thigh-bones can be handled, with care.

About five miles north of this are other mounds, located on the banks of Running Lake. There are four mounds in this group, but only two have been opened. Some years ago it became necessary to build a bridge across the lake at the site of the mounds. The dirt for this purpose was taken from two of them, leaving about one-half of each. The skeletons appeared to be scattered promiscuously through the earth composing the mounds, and no stones were placed around them. These mounds are formed of black sand and gravel mixed in with pieces of shell. There are also found pottery-ware, stone and flint spear-heads, stone axes, &c. The pottery has been in the ground so long that it is almost impossible to preserve it.

Between these mounds and those five miles south appears from the remains to be what was once quite a settlement, which is now, however, covered with a dense forest of large growth, as well as the crumbling trunks of trees half hidden in the accumulating soil.

In Pope County, in this State, and about fifty miles east of this, there is another very interesting earth-work. It occupies the summit of the highest hill, very steep, and with but one approach, and this is protected by a stone and earth embankment across a narrow neck. The defenses consist principally of stone work. Some of the stones are very large, and yet have been brought from some other point, as none of the same formation are found in this hill. Of course nothing like a true wall now exists. This remain is known as the stone fort.

Within a mile of this place, and on a high ridge, are two sepulchral stone circles, but nothing has been found in them. They are evidently very ancient.

Since writing you I have made another visit to the mounds in the "Mississippi bottom," and as I have obtained some rather interesting additions to what I communicated before, I have concluded to write again. We first opened the mound described as the large mound in front of the opening of the earth-works. It was my intention to have dug a ditch through the mound, but the weather was so warm the men could not endure the work, so I commenced by sinking a hole in the center where the depression which I mentioned exists. After going down about three feet we came to what looked like a chimney made of sun-burned brick, and on removing some four feet of this we came to the foundation. We then ditched both ways, east and west, and came on one side to a wall, on removing the earth from which, we found it to be arched. The arch appeared to have been formed in three layers of stone with a layer of grass between each, but looked as though it had been exposed to fire. At the bottom and around the chimney there appeared to have been placed a matting made of cane, but not firm enough to be moved only in small particles. Here we found earthen pots respectively of the capacity of one, one and a half, and two gallons; the large pot was unfortunately broken in removing it. I also found an image, but differing from the other one I found; this one is hollow and holds half a pint, with a good face and a fine bust. It is evidently intended to represent a woman with the arms hanging on the side, and the hands folded across the abdomen; the opening is on the back of the head. I also found a small ornament of rock crystal three-fourths of an inch long, with a small hole through one end; in color it is a beautiful purple, and perfectly translucent. This mound, I am under the impression, was a dwelling-place, from the fact that nothing indicated that it has been used for anything else. Furthermore, we found under the arch a large quantity of charcoal, which appeared as if it had been burned in the place. The arch, we ascertained by digging holes, run through the mound from east to west, and is about six inches thick. I have no doubt but that this is quite an interesting mound, and if properly examined would show much relative to the habits of the mound-builders.

I forgot to mention that I found one of those stones with a hole through it, known in this vicinity by the name of "tool-stones;" it is about two inches in diameter. I also found three handsome flints.

ANCIENT MOUNDS IN KENTUCKY.

By Dr. Robert Peter, of Lexington, Kentucky.

I have the pleasure to forward to the Smithsonian Institution, by Adams Express, to-day, a small box, containing a portion of the relics found by my sons and myself in the small ancient mound which we opened on the 19th of October last, to wit: Some of the red earth in which the relics were imbedded, with fragments of much-decomposed bones, charcoal, &c., a number of *flint implements* of various shapes, portions of *soft sandstone* which seem to have been used for grinding or polishing implements, a broken *door-button-shaped* article of the white compact sulphate of baryta, found here in veins in our limestone, and a *rude pipe* which has been made of soft sandstone.

The mound is about fifty feet in diameter, not rising in the center more than three feet above the general surface of the woodland pasture in which it is located. Trees as large as any in the woods around grew on the mound, which seemed of sub-soil earth thrown up on the natural surface.

The flint implements were mostly found arranged in an elliptical figure, they being laid end to end, overlapping each other.

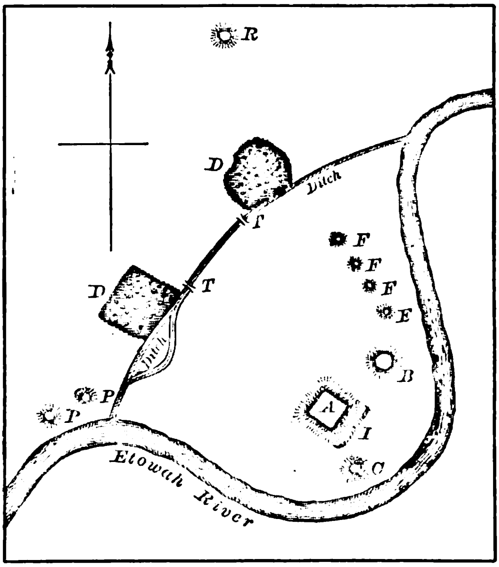
A little rude, copper bead was found in the earth, which seemed to have been accidentally dropped there.

This mound is on the farm of Mr. Jer. Tarlton, close to the boundary-line of the farm belonging to myself. It lies about a mile from the other small mound, on the farm of Mr. G. Fisher, (on North Elkhorn Creek,) from which we obtained the copper articles, &c., last forwarded by me, and is one of the series of ancient works mentioned in my communication published in the Smithsonian report for 1871.

MOUNDS IN BARTOW COUNTY, NEAR CARTERSVILLE, GEORGIA.

By M. F. Stephenson.

The most extensive and perfect series of tumuli exist in Bartow County on the Etowah River, near Cartersville, a sketch of which I send you:



A, large mound, 88 feet high. B, circular mound, 65 feet high. C, pentagonal mound, 25 feet high. D, excavation of an acre. F, mounds. I, terrace, 20 feet high P R, mounds outside. T, crossings. Area inclosed by ditch and river, fifty acres.

It consists of ten mounds, situated in the bend of the river, and protected from attack on the land side by a moat, which is from 20 to 30 feet deep, and doubtless was once filled with water. The central mound is square, and measures 150 feet on top,* with raised platform on the east side 20 feet high and 40 wide; probably sacrifices were offered here, as an idol of sandstone was plowed up at this place, with excavated disks or mortars, 6 inches in diameter and of translucent quartz, of elegant workmanship; also a stone ax, a small native copper vessel, a perforated marzenella shell, (which is found in all the mounds,) a mica mirror, and the only gold beads ever met with—native gold being found in the neighborhood. This mound is 88 feet high, and a few rods from it is a circular one 65 feet high, which twenty years ago had a parapet on top 5 feet high. The remainder are small and only about 20 feet high. There are two excavations an acre square, as deep as the moat, from which earth was probably obtained to raise the mounds.

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* It is not exactly a quadrangle, but the north side is 150 feet, the eastern side 160 feet, southeastern side 100 feet, south side 90 feet, and the western side 100 feet.

The valley and country for twenty miles westward and northward is very fertile, and exhibits evidence everywhere of having been densely peopled by the mound-builders.

At the falls of Little River, near the Alabama line, on the crest of the fall, are three chambers hewed out of the solid sandstone, and at Nacoochee the crest of a conical hill is cut off at about 50 feet, so as to embrace an acre and a half; on two sides this is quite precipitous, and on another a ditch and wall, which formerly was 6 feet high, inclosing 20 acres, used by De Soto in the battle he had with the Cherokees in 1540, which is proved by the relics found.

At Macon are stupendous remains, as also in Campbell County on the Chattahoochee. Among these is the Yond Mountain, 4,000 feet high, of solid granite; it is a cone crested with trees, nearly perpendicular on all sides except at one place, which was walled with stone: Also the Stone Mountain, which is without vegetation—2,360 feet high—a cone, and accessible on one side only. This was walled with stone. All defensible mountains in this country were fortified. Neither the Cherokees, Creeks, nor Seminoles had any tradition of the extinct race, which is proved to have been a powerful nation, from the extent of their territory and the stupendous character of their fortifications and cemeteries.

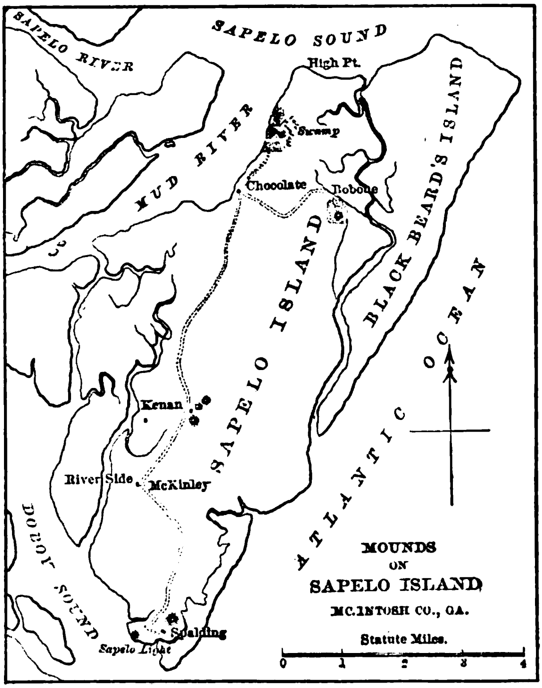
MOUNDS IN GEORGIA.

By William McKinley, Milledgeville, Ga.

There are many groups of mounds in Georgia, an account of which would be of importance to the archæologist to have permanently recorded. With this view, I send you an account of mounds on Sapelo Island, McIntosh County.

South of High Point there are three mound-circles, having plain areas. No. 1 is 240 feet wide; 9 feet high; base, 30 feet; no gateway; built of earth and shells, densely overgrown with live oak, palmetto, myrtle, grape-vines, which perfectly mask it; western side built along the very edge of the table-land, so as to front a salt marsh and Mud River as a wall 20 feet high; on the north, skirting a fresh-water flag and bulrush marsh or stream, 150 feet wide, separating it from circle No. 2, which is 210 feet wide, in an open field long cultivated; mound now rising 3 feet on 20-feet base, composed of shells and earth; area plain. Circle No. 3 is 150 feet wide, just like No. 2.

These circles are surrounded by hundreds of shell-mounds, about 3 feet high, on bases of 20 to 50 feet, which crowd, without visible order, a field of one hundred acres or more, bounded on the west by salt marsh and inland salt river, and on the east by fresh-water jungle. On all these shell-mounds and over all this plain are found fragments of Indian pottery, both plain and ornamented. No funeral mounds are nearer than three miles. The shells are all of mollusks yet living in the neighboring waters, the oyster, clam, conch, scallop, &c., which fact, and the broken pottery, show plainly that these shell-mounds, indicated by dots on the map, in countless number, are ancient camps of the Indians or mound-builders, where they dwelt, while the three great mound-circles were doubtless for councils or games. The big circle, yet perfect, was probably the "pow-wow" or state house, and place of torture of captives, "chunk-yard" of the Uchees; it was certainly the most important; while the other two were perhaps for dances and athletic sports and games. These three circles and this field of thickly set, countless shell-mounds, are on the west shore of Sapelo Island. The cemetery or funeral mounds are found far off—three at Kenan, six miles southerly; one very large one at "Druid Grove," or "Spalding," ten miles off; and two on the eastern shore on Blackbeard's River, three miles off. None others are known; but very much of the intervening central part of the island is impenetrable palmetto thicket, and it is possible other mounds exist in this



thicket. These cemetery-mounds are very ancient. Sapelo Island is famous for its wonderful moss-hung live oaks; but the largest bodied tree on the island, one over 4 feet in diameter at the stump, and 7 feet in height, to just below the first fork, grows on top of the biggest burial-mound at the place marked "Kenan." Considering the great compactness of live-oak, this tree is probably six hundred years or more old. How old, then, is the mound? It is yet about 8 feet high, on a base of 50 feet diameter, a little elliptical, situated in an open field, and covered with live oak and cedar.

The big mound on the east side, at Bobone field, (negro corruption of Bourbon, as the old French colonists called it,) is yet 9 feet high, or more, 70 feet in diameter, and is circular in form. The negroes report it full of pottery and men's bones. I hope soon to send you specimens of its pottery and implements. It stands on the inland tide-marsh side, near the south end of a field of seventy-five acres, the entire surface of which field is dotted and white with hundreds of shell-mounds, from 2 to 4 feet high, and from 15 to 50 feet base. Broken pottery and broken stone implements from the far-off mountain quarries are found here, as at the circle-mounds on the west shore; but, so far, not a weapon of fight, or of the hunter, of any sort, large or small, has been found on Sapelo. I find the tanner's tool, but no weapon of death. This fact is very remarkable. On the main-land, in the hill region of Middle and Upper Georgia, almost every acre has its ancient stone weapons, its arrow-heads, javelins, dirks, slung-shot, or battle-axes; but the ancient fishermen of Sapelo—its forgotten mound-builders—either had no weapons of war, or they were not of stone, and have perished. At least none are found or heard of now. If any ever existed there, they must be buried in the mounds. However, I will soon know, as my young friends on the island, and Mrs. Spalding, all of whom enter ardently into my explorations, will, in the course of this year, get the negroes to open the mounds, and will send me the relics for the Georgia department in the museum of the Smithsonian Institution.

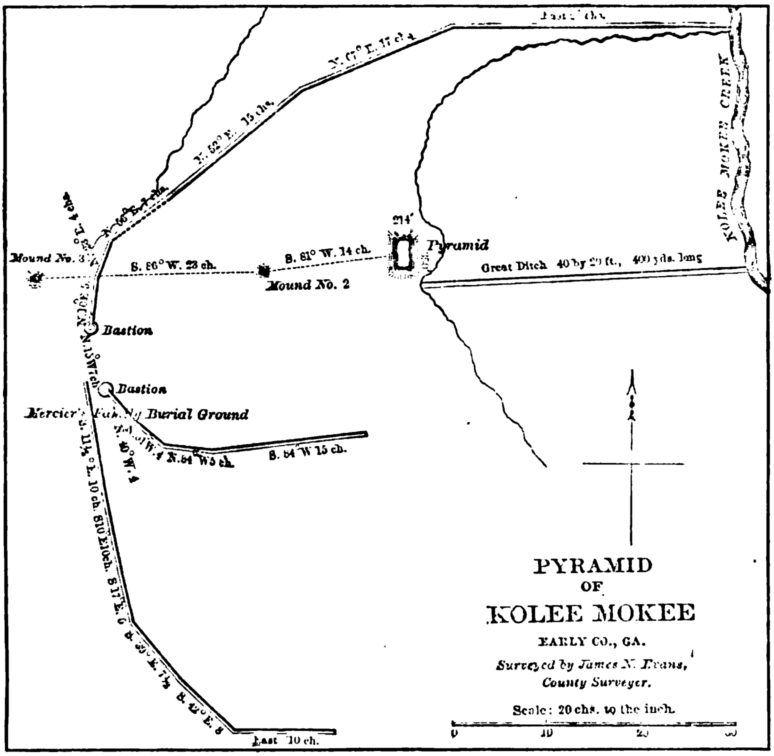
In the meanwhile I will procure a survey of the mound-fields of Southwestern Georgia, as you request; and perhaps, too, of the chain of Ockmulgee mounds, which are very large cones.

* * * * * * *

The two groups of mounds which I have had surveyed by James N. Evans, at the expense of the Institution, are in Early County, Ga. One group is near Kolee Mokee Creek, and the other at Dry Creek.

The following is a representation from actual survey of the position and form of the mounds and earth walls on Kolee Mokee Creek, in Early County, Georgia. They are principally on a plantation now occupied by Mr. A. J. Mercier. I say principally, because the eastern portion of the walls extends over on to the plantation of Judge Joshua Harris.

In the investigation of these ancient remains we began by measuring the large pyramidal mound, which we found of the following dimension: Circumference, 1,128 feet; length of base, 350 feet; width of base, 214 feet; length of plane of summit, 181 feet; width of plane of summit, 82½ feet; sloping side, a little diagonal, 125 feet; estimated height of pyramid, 95 feet.



PYRAMID
OF
KOLEE MOKEE
EARLY CO., GA.
Surveyed by James N. Evans,
County Surveyer.

The plan of the base, and also that of the summit of this pyramid, may be said to be rectangular, their length and breadth being as stated above. The direction of the longer side of the mound is N. 10° W., varying only 10° from a due north and south line. At the south end of this pyramid there is a pit from which it is supposed the earth of which the mound is composed was originally excavated. A well has been at some time sunk into about the center of this mound to a considerable depth, probably in search of treasures, but apparently without success.

Starting from the middle of the western side of the base of the pyramid and running S. 81° W. 14 chains, we arrive at a conical mound, which I have denominated No. 2. The circumference of this mound is 216½ feet; the diameter 72 feet; the sloping side 43½ feet; the height of axis of cone 24 feet. From the west side of mound No. 2, running S. 86° W. 23 chains, we come to mound No. 3, which has a diameter and a height nearly the same as those of No. 2. At a distance of 17 chains from the western base of mound No. 2 we come to the inner wall, or breastwork. Commencing at the eastern terminus of the southern wing of the wall, the courses and distances along it to a bastion marked "Mercier's burial ground," are as follows: S. 84° W. 15 chains; N. 84° W. 5 chains; N. 51° W. 4 chains; N. 40° W. 4 chains. From this bastion to the other bastion there is no appearance of a wall.

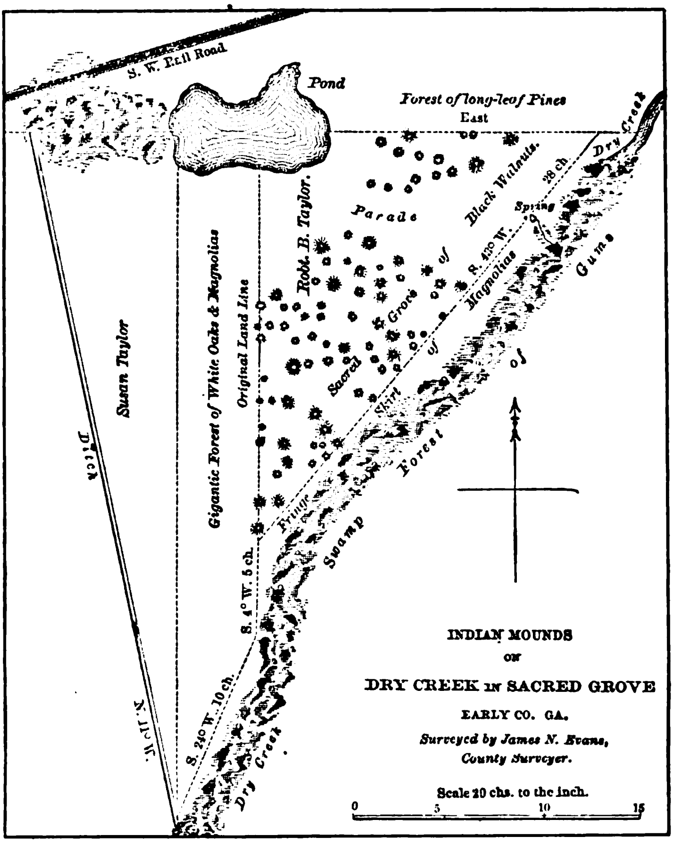
From bastion No. 1 to bastion No. 2, the direction is N. 15° W., distance 7 chains. From bastion No. 2 the courses and distances along the northern portion of the outer wall to Kolee Mokee Creek are as follows: N. 10° E. 5 chains; N. 23° E. 4 chains; N. 56° E. 7 chains; N. 52° E. 15 chains; N. 67° E. 17 chains; E. 29 chains to the creek.

The southern portion of the outer wall has its starting-point near the southern or No. 1 bastion, which is not parallel with the inner wall, but runs as follows: S. 11½° E. 10 chains; S. 10° E. 10 chains; S. 17° E. 5 chains; S. 39° E. 7½ chains; S. 42° E. 8 chains; E. 10 chains to its terminus. The wall in the woods is a little more than 1½ feet high—that in the plantation not exceeding 15 inches, the former having been protected from the effects of cultivation. The base of these walls is at present about 30 feet wide, probably much greater than they formerly were. They very gradually slope from base to middle. One of the oldest citizens in the county tells me that he has seen these walls when they were at least double the height; they have gradually decreased in elevation and increased in breadth of base. I have also been informed that some of the facial bones of human skeletons have been taken from one of the mounds in the Mercier plantation, which are said to have been much larger than those of our own race, leaving the inference that the mound-builders were almost of a giant stature, but this tradition may be the result of the natural tendency to indulge in the marvelous.

While engaged in the field-work I noticed a large number of fragments of carved ware and arrow-heads along the line of the walls and about the mounds, both on Kolee Mokee and on Dry Creek.

The following sketch represents a piece of land on Dry Creek known as the Walnut Fork, on which are situated ancient mounds in great numbers. The area of the whole lot is fifty-one acres, and is of a triangular form, bounded on the east by the swamp-ground of Dry Creek, and on the west by a ditch which was once occupied by a small stream emptying itself into Dry Creek. The portion of this lot which is occupied by the mounds consists of about twenty-one acres.

The mounds are eighty-three in number, although some of them are now not very distinct. To give a minute description of each of these small mounds would occupy considerable space, and add but little to the interest of the subject. It will be sufficient to say that they vary in height from that of a few inches to 10 feet, and in diameter from 15 feet to 100, there being a single one of the latter size, but most of them are from 30 to 40 feet. Nearly all those of medium size are parapeted. The largest one and some of the smaller are convex on the top, while others are concave or level. They do not appear to have been arranged in accordance with any definite plan, but are scattered about promiscuously on the northern boundary of the lot. Several mounds are situated on an east and west line.



It will be seen by a reference to the diagram that there is a spring marked on it, and that there is an open space free of mounds between this spring and a pond to the west of it. We know not for what this open space was intended, but there cannot be any doubt that there was a design in the arrangement. It may have been used as a parade-ground or for games. From the fact that human bones have been exhumed from some of these mounds, we are led to the conclusion that they are places of sepulcher. The great pyramid of Kolee Mokee is the only one of this form in Georgia, while the large mound of Dry Creek is entirely unique in all its main features. It is evidently a mound of sacrifice. A little stone idol was found on it. The site of this group of mounds is covered with a grove of black-walnut trees 100 feet high, and the mounds themselves are hidden in the depths of the almost impenetrable swamp, so as to be wholly unknown, until lately, even to the oldest inhabitants of the neighborhood.

* * * * * * *

I have the pleasure of reporting further collections of relics—weapons, mortars, tools of art, perforated stone implements of extreme hardness, perfectly bored with a spiral auger; arrow-heads of jasper, obsidian rock crystal, hornstone, and moss-agate; and, last and best, to-day I have obtained from the Oconee River swamp a *funeral urn*, like those of Japan, with a close lid, 14 inches high by 12½ inches middle diameter, containing human relics, very discernible fingers, bones, &c., which soon moldered away after exposure to the air. The urn, which is of clay, is covered all over with elaborate etchings of what I take to be written characters. The lid was left in the swamp, but will probably be found, and come to me sound or broken. When my collection is more increased, I will send all my specimens for the Georgia department of the Smithsonian Institution.

In regard to the discovery of the urn which I have mentioned, allow me to congratulate myself as a collector, but I beg you to inform me whether my exultation is unreasonable. Am I right in thinking that "funeral urns" have not before this been found in the United States? I think I have found a rich field and a new one for discoveries of this kind.

INDIAN REMAINS FOUND 32 FEET BELOW THE SURFACE, NEAR WALLACE LAKE, IN CADDO PARISH, LOUISIANA.*

By T. P. Hotchkiss, of Shreveport, Louisiana.

In July, 1862, W. H. Waldrum, while engaged in digging a well on the edge of Post-Oak ridge, one and a half miles from Wallace Lake, after passing through the thirty-two feet of earth came upon an Indian grave.

First.—Description of strata from surface to grave.

1. Soil about 4 feet like post-oak soil, but mixed with some sand from washings of hill-side.

2. Red clayey earth, which, dissolving almost as freely in water as sugar, and of near the same specific gravity when in suspension, extended down to the leafy deposit. This red deposit underlies nearly all this country, extending to the very sources of the river, usually immediately under the soil, and furnishes the coloring matter of Red River.

3. Mushy, rich ground, mixed with undecomposed leaves and branches of trees.

4. Small muscle-shells mixed with a sandy deposit for 5 or 6 feet. In this deposit were found the bones and darts placed side by side, with a slight lap, the points directed from the body. The largest spear was

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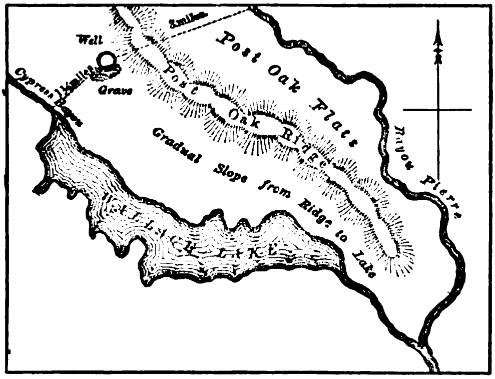
* Now in the National Museum, Washington.

11½ inches in length. They were four in number and wrought from pure flint-rock.



Second.—Description of strata below the grave to depth of the well.

1. Immediately below the grave a red deposit, like clay, 20 feet.
2. Then four feet through white clay.
3. And remainder of the distance through blue clay, until water was found 71 feet below the surface.

The ancient crockery, &c., I send you was found one and a half miles above Shreveport, in Bossier Parish, at a cut-off made in Red River by the swamp-land commissioner in 1859.

Eighteen feet beneath surface, through Red River soil to the deposit —which underlies all the red soil of the valley—the washing of the river has exposed a large burial-ground, containing numbers of remains of bodies and of articles buried with them, such as implements of cooking, jugs, plates, &c., of a peculiar workmanship; also, remains of something, supposed to be a turtle.

MOUNDS IN LOUISIANA.

BY PROF. SAMUEL H. LOCKETT, OF THE LOUISIANA STATE UNIVERSITY, BATON ROUGE.

While prosecuting my topographical survey of Louisiana this summer I visited, near Jackson's Ferry, four miles south of Floyd, on Bayou Maçon, some very remarkable Indian mounds. Six of these are within a mile of Mrs. Jackson's. Four of them are almost perfect; the other two are partly destroyed by the caving of the banks of the Bayou Maçon. They are connected with each other by a levee or narrow embankment of earth, making a nearly semicircular figure. There are two much larger mounds nearer to Floyd, one on Mr. Mabin's, and one on Mr. Motley's land. The latter must be between 20 and 30 feet in height.

On the sides of all of the mounds, and in their vicinity, are found great numbers of relics, such as human bones, arrow-heads, "plumb-bobs" very perfect in form, and immense quantities of broken pottery. Many of the pieces of pottery are highly ornamented. From the quantity of pottery, I imagine there must have been a factory of this ware in this locality. Excavations would in all probability reveal some very valuable and interesting specimens, and I think it should be done by one accustomed to searching for archæological remains.

PRE-HISTORIC REMAINS FOUND IN THE VICINITY OF THE CITY OF WASHINGTON, D. C.

By T. R. Peale.

The positions chosen by the ancient inhabitants of this country for their temporary or permanent occupation were generally at the mouth of smaller streams emptying into larger ones, or on jutting points of land favorably situated for hunting and fishing, and which could be readily defended against the attacks of an enemy. Wherever such places occur, in almost any part of the United States, remains of the ancient inhabitants are to be found in greater or less numbers. These remains are, as a general rule, more numerous on the border of fresh-water streams in the interior of the country than on the coast, which appears to have been visited periodically for fishing in the intervals perhaps of the hunting seasons and those of the cultivation of Indian corn. The stone implements may also be found in less numbers along the southern coast, because the minerals out of which they were fabricated do not exist on the sea-board much south of the latitude of the city of New York.

The site of the city of Washington, and its vicinity, must have been a favorite locality for at least the temporary residence of the ancient people, since the remains of their implements are found in great numbers at different points, especially along the river. It does not appear that the implements were manufactured here, as heaps of the *débris* or chippings are not met with, as in other localities. It is probable, however, that some of the arrow-points were made here, for though the material of which they are composed is not found in place, yet they occur in sufficient quantity in the bowlders of the northern drift, which appears to be terminated in the interior of the country, in about this latitude. That part of the city on which the arsenal stands, called Greenleaf's Point, was evidently a camping ground, since numerous specimens of arrow-heads and other perfect articles have been found in this locality. The point of land at the mouth of what was called the Tiber, near the Washington monument, is another locality on which specimens of the kind in question are found. But I have found the greatest number of these implements on the west side of the Potomac, directly opposite the city, along the shore from Analostan Island to the Long Bridge. The number of remains found here is supposed to warrant the conclusion that this was a favorite resort of the ancient people. From Analostan Island to the Long Bridge, the remains of pottery and stone implements are sufficiently numerous to warrant the conclusion that the whole space was occupied, either at once or at many times, as a continuous town. This space, which now forms a part of the main land, was apparently once an island.

Another locality which exhibits abundance of remains is at the Little Falls of the Potomac, about five miles above the city. At this place, on either side of the river, on the rising ground, the implements are found. They consist of arrow-heads, hatchets, chisels, and earthen ware. This locality was probably resorted to for fishing, as it is at the present day. The fish, ascending the rapids in the spring to deposit their spawn, were readily caught by the spear, the net, and the line—the use of the latter being indicated by the number of stone sinkers which are found.

The materials of which the stone implements are formed consist of quartz, jasper, and slate or horn-stone. The latter is not found in this vicinity in place, but in the drift. At least four-fifths are of quartz. The arrow-heads, as usual, are of two kinds, one apparently for war, and the other for the chase; the first is of a triangular form with a re-entering angle at the base, by which it was attached to the shaft in a notch at the end. This form of arrow was adopted in order that when the shaft was withdrawn from the wound, the arrow-head might remain. The other arrow-head is also of a triangular form, with sides slightly convex, but terminated at the base with a projecting point forming two notches, one on each side, by which it was permanently attached by thread, probably of sinews, to the shaft. The second form of arrow-head is by far the most numerous. Besides the arrow-heads, there are found many of the fragments of quartz which are in reality perfect instruments intended for cutting, carving, &c. When these are critically examined they are seen to have a cutting edge or a point carefully worked, while the opposite side is left rough to be inserted in a handle of wood or horn, which completed the perfect instrument. In some of the specimens there are notches on the upper side of the knife or chisel by which they could be more securely fastened to the handle. The other implements, hatchets, adzes, chisels, and hammers, are usually made of trap-rock, which is found among the bowlders of the drift. Some of these are polished with care. Pestles of the same material are also found, though these are not as numerous as in other localities, particularly in those of Pennsylvania.

Fragments of pottery occur of porous clay, hardened in the fire, and almost in all cases ornamented with impressions of the corn-cob, indicating the use of this article of food at an early period, and marking a point in the civilization of the people. The fragments have never been found of sufficient size to indicate the original form of the vessel.

In this connection it may be stated, in relation to the large shell-heaps which are found along our coast, that it is probable they were formed by periodical visitors who annually resorted to the sea-shore for a supply of shell-fish for food. It is said that within the historic period the Indians on the coast of New Jersey were in the habit of opening their oysters and clams by the aid of fire, and of drying them on strings for winter food. A custom of this kind would account for the remains of pieces of charred wood which are found in these heaps without adopting the hypothesis that they were the sites of kitchen mœddings. These heaps were the result, perhaps, of thousands of years' accumulation.

It may also be remarked that on high ground I have generally found no other implements than those which were used for the purpose of war. This would appear to indicate that they were buried with warriors and chiefs, according to the custom of the Indians of the present day, on prominences, or elevated jutting points of land. Comparisons of this kind are of importance to the study of archæology, in the way of explaining facts of the past by reference to the usages of peoples of the present in the same state of civilization.

CATALOGUE OF A CABINET OF INDIAN RELICS COLLECTED BY J. H. DEVEREUX, OF CLEVELAND, OHIO, FROM THE YEARS 1848 TO 1868, INCLUSIVE, AND PRESENTED BY HIM TO THE SMITHSONIAN INSTITUTION.

Miscellaneous implements.

1 to 26, inclusive. Knives or chisels, from Tennessee.
27. Skinning-stone, from Ohio.
28. Hatchet or pick, from Ohio.
29. Skinning-stone, from Ohio.
30. Skinning-stone, from Ohio.
31. Hatchet or pick, from Ohio.
33. Chisel, or perhaps bark- or wood-wedge, from Ohio.
34. Chisel, or perhaps bark- or wood-wedge, from Ohio.
35 to 36. Tomahawks, from Ohio.
37. Skinning-stone, from Ohio.
38 to 40, inclusive. Skinning-stones, from Ohio.
41. Chisel, from Ohio.
42. Skinning-stone, from Ohio.
43 to 51, inclusive. Skinning-stones, from Ohio.
52. Skinning-stone, from Tennessee.
52 to 58, inclusive. Skinning-stones, from Ohio.
59. Skinning-stone, from Tennessee.
60. Skinning-stone, from Ohio.
61. Hatchet, from Ohio.

62. (?), from Ohio.
63 and 64. Hatchets or picks, from Ohio.
65. (?), from Erie County, Pennsylvania.
66. Pipe (?), from Erie County, Pennsylvania. It was dug up, and shows spade-mark. The blackening of orifice was caused by a boy charging it with gunpowder and seeking to use it as a cannon.
67. Pestle, from Ohio.
68. Pipe, taken from Indian grave, from Ohio.
69. Gorget, from Summit County, Ohio.
70 and 71. Amulets (?), from an Indian grave. Ohio.
72. Gouge, from Ohio.
73. Spear-head, from Tennessee.
74. Spear-head, from Ohio.
75. Chisel or wedge, from Massachusetts.
76. Gouge, from Massachusetts.
77. Pestle, from Massachusetts.
78. (?), from Massachusetts.
79. Pestle, from Ohio.
80. Totem, from Ohio.
81. Skinning-stone, from Tennessee.
82. Hatchet, from Ohio.
83 and 84. Skinning-stones, from Ohio.
85 to 88, inclusive. Skinning-stones, from Tennessee.
89. Chisel, from Tennessee.
90 and 91. Skinning-stones, from Tennessee.
92. Ax, from Ohio.
93. Ax, from Tennessee.
94. Pestle, from Tennessee.
95. Ax, from Ohio.
96 to 98, inclusive. Mortars or pallets, from Tennessee.
99. (?), from Tennessee.
100 and 101. (?), from Tennessee.
102. Ball, from Tennessee.
103. Ball, from Tennessee.
104. Horn or trumpet (?), from Tennessee.
105. Grinder?
106. Ball, from Ohio.
107. (?), from Tennessee.
108. (?), from Indian grave, Tennessee.
109. (?), from Tennessee.
110, 111, and 112. (?), from Tennessee.
113 and 116, inclusive. Knives, from Tennessee.
117 and 118. (?), from Tennessee.
119. (There should be two more of these found in box sent containing the pottery.) From a grave in old Indian burial-place, Clarksville, Tenn.

120. Sledge of ancient copper-workers, lake Superior.

121. Hatchet, from Massachusetts.

122. Knife, from Massachusetts.

123. Pipe, Indian (?), plowed up in a field in which several arrowheads were found, from Massachusetts.

124 to 155, inclusive. All from Western Reserve, Ohio.

156. Chisel, from Ohio.

157 and 158. (?), from Ohio.

159. Pipe, Indian (?), plowed up near a small mound. From Ohio.

160. (?), from Ohio.

161. Horn or trumpet, from Ohio.

162. Horn or trumpet, from Ohio.

163. Pipe, from an ancient mound in Tennessee. It was given to me by Mr. John Pierce, of Hudson, Ohio, whose father was president of the Western Reserve College, located at Hudson, and where I was visiting at the time of the gift, about 1852. Young Pierce told me this pipe, with two others, had been sent to one of the former professors by some former graduates of the college who had gone to Tennessee. Young Pierce *was positive* as to the fact that it was a relic from an *ancient mound*, and searched for the original letter accompanying the pipes, which he said contained full and authenticated details of their discovery. But the letter could not be found. I have no doubt whatever of the facts as stated relative to this relic.

164. Fragment of one of the other pipes, which was found with specimen 163, as above.

165. Sioux pipe, smoked at a council between some missionaries going from Western Reserve College to Western Missouri about 1837 to reclaim the Sioux Indians, and by the missionaries forwarded to President Pierce, of said college, whose son presented me with the relic.

166. Pipe of a Lake Superior chief, 1850.

167. *Copper* ornament, found with human bones in a small *Indian* mound near Painesville, Ohio. Hatchets and arrow-heads were mingled with the remains.

168. Brooch from breast of skeleton in old Indian grave-yard, Conneaut, Ohio.

169. (?), from a mound, Ohio.

170. From Ohio.

171 to 173, inclusive. Beads from an Indian grave, Tennessee.

174. Pipe from an *ancient mound*, Tennessee, found and given to me by Professor Safford, State geologist, about 1858.

175. Arrow-head from Lake Superior.

176. Fragment of (knife ?), Tennessee.

177 to 182, inclusive. Arrow-heads from Ohio.

183. Arrow-head, remarkable for symmetry and finish, picked up

in Franklin County, Southern Central Pennsylvania, within 600 feet of the ancient war-lodge of the Senecas.

184 to 186, inclusive. Arrow-heads from Tennessee.

187 to 196, inclusive. Fragments of pottery, from some very remarkable mounds, three miles southeast of Franklin, Williamson County, Tenn.

197. Fragment of pottery, from South Hadley, Mass.

198. Fragment of pottery, from mound in Ohio.

199. Fragment of brick, from mound in Iowa.

200 to 203, inclusive. Fragments of pottery, from mounds in Georgia.

204 to 206, inclusive. Fragments of pottery, from mound in Maury County, Tennessee.

Arrow-heads.—Three packages of these were sent in one of the boxes, respectively collected in the New England States, in the Western States, and in the Southern States, and the aforesaid division of States marked on the packages accordingly. It had been my aim to collect arrow-heads of the various tribes of Indians, and to have preserved them thus distinct in the cabinet; but I found that the differences in shapes, style, &c., were so slight (if at all distinct) as not to justify the trouble.

Ancient pottery.

All of the pottery sent is from an ancient burial-place in Arkansas, with *one* exception—a portion of a bowl, (say one-half,) broken, I think, in two pieces, and in appearance so very thick and clumsy, compared with the other specimens, that its recognition is a matter of no difficulty. This bowl is from an Indian grave at "Hamilton Place," (residence of Gen. Lucius Q. Polk,) Maury County, Tennessee.

At "Maple Grove," Maury County, Tennessee, February 7, 1860, Jerome B. Pillow, esq., (brother of Gen. Gideon J. Pillow,) made the following statement in regard to the ancient pottery discovered by him, and then and there presented to me:

"The spot where this pottery was found is in Phillips County, Arkansas, adjacent to the Mississippi River, and (measured along the river) eighteen and three-fourths miles below Helena."

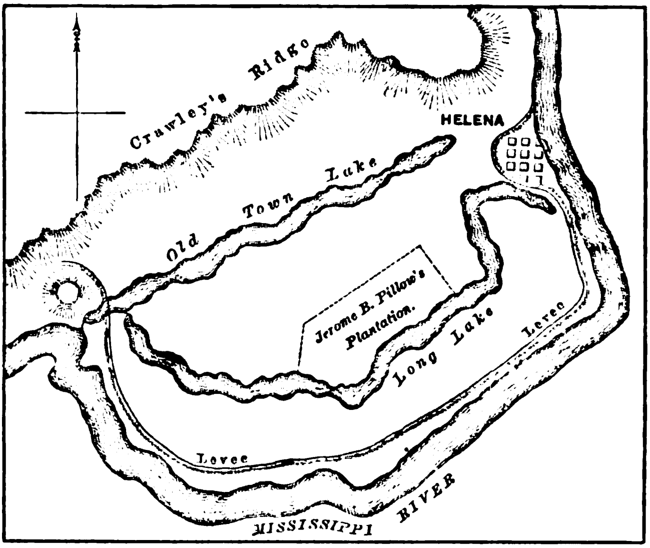
A map of the locality is given in the accompanying Fig. 1.

The point designated A is the ancient burying-place where the pottery was procured.

In the construction of the levee across Old Town Lake and Long Lake a vast quantity of earth was required to make the embankment, and to procure which Mr. Jerome B. Pillow commenced removing material from a site which proved to have been a most extensive cemetery. Hundreds of human skeletons of all ages and of both sexes were exhumed, and with them many specimens of pottery of varied shapes and sizes. The skeletons were found buried in a sitting posture, and from three to ten feet below the surface; the bones in all cases in a perfect state of preservation.

Trees from three to five feet in diameter were growing over the graves, one, a "sassafras," five feet in diameter, had come to maturity, died, then withered away, leaving only its roots in a sound condition. The negro laborers, with superstitious terror, would fain have fled from their work on the first discovery of the bones, and they were persistent in destroying the pottery to prevent its removal. Their aim was to conceal in the dump or embankment both bones and pottery. It was, therefore, with some difficulty perfect specimens were procured by Mr. Pillow, and those obtained (my gift comprised about one-third of the number) were brought to his residence in Maury County, Tennessee. In this rare collection there was one vessel, capable of holding half a gallon, in the shape of an animal. It bore great similarity to a vessel, which some time before I had examined, brought from the pyramids, Egypt, by the Rev. Dr. Burgess, of Dedham, Mass.

Fig. 1.



ON THE ACCURACY OF CATLIN'S ACCOUNT OF THE MANDAN CEREMONIES.

By James Kipp.

We publish the following letter as an act of justice to the memory of the late Mr. Catlin, and as a verification of the truth of his account of a very interesting ceremony among the Mandan Indians, a tribe now extinct. The ceremony was especially interesting in its resemblance to some of the self-inflicted tortures of the devotees of eastern superstitions.

In regard to the remarks relative to Mr. Schoolcraft, it is but justice to state that we were intimately acquainted with him, and cannot for a moment harbor the thought that he would have done anything to disparage the veracity of any one from any other motive than a desire to promote the truth. The statements of Mr. Catlin were at the time so remarkable, the ceremonies which he described being so unlike those of other Indian tribes, that Mr. Schoolcraft was justifiable in receiving the account with doubt, although he may have expressed his disbelief in stronger terms than he would have done had he been more intimately acquainted with the character of Mr. Catlin than he appears to have been.—[J. H.]

BARRY, *Clay County*, *Mo.*, *August* 12, 1872.

DEAR SIR: Though a stranger to you, I take the liberty of addressing you this note as important to science and to the ethnology of our country, as well as important to the reputation of one who has devoted much of a long and hazardous life in portraying and perpetuating the customs of the dying races of man in America. Mr. Schoolcraft sent me, some years past, a copy of a large work he had published for the Government of the United States on the North American Indians, and of which work some thousands of copies were presented by the Government to the libraries of the institutions of the New and the Old World. In this work I find that Mr. Schoolcraft denies the truth of Mr. Catlin's description of the Mandan religious ceremonies—the truth of his assertion that the Mandan youths suspended the weight of their bodies by splints run through the flesh on the breast and shoulders, &c.; and asserts, also, that his whole account of the Mandan religion is all wrong. It is a great pity that Mr. Schoolcraft, who never visited the Mandans, should have put forth such false and unfounded assertions as these on a subject so important to science, and so well established by proved facts.

I had the sole control of the American Fur Company's business with the Mandans, and lived in their village, for the space of thirteen years, from 1822 to 1835, and was doubtless the first white man who ever learned to speak their language. In the summer of 1832 Mr. George Catlin was a guest in my fort at the Mandan village, observing and learning the customs of those interesting and peculiar people, and painting the portraits of their celebrated men, of which he made many and with great exactness. It was during that summer that Mr. Catlin witnessed the Mandan religious ceremonies, the O-kee-pa described in his notes of travels among the North American Indians, and to which Mr. Schoolcraft has applied the insulting epithet of falsity in his great work. By the certificate published by Mr. Catlin, signed by my chief clerk and myself, on the 28th day of July, 1832, in the Mandan village, certifying that we witnessed, in company with Mr. Catlin, the whole of those four days' ceremonies, and that he has represented in his four paintings, then and there made of them, exactly what we saw, and without addition or exaggeration, it will be seen that I witnessed those scenes with

Mr. Catlin and interpreted their whole meaning for him as they are described in his work. Since the extinction of this friendly tribe, and the end of this peculiar and unaccountable custom, and in the eighty-fifth year of my own age, from a sense of duty to my ancient friend Mr. Catlin, and a wish for the truthfulness of history, I have taken the liberty of committing to your care and for your use, as you may be disposed, the foregoing statements.

Yours, truly,

JAMES KIPP.

Professor HENRY,
Smithsonian Institution.

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